THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXI.—*On the Gases contained in Meteorites.* Second paper; by ARTHUR W. WRIGHT, Yale College.

IN a previous article, published in this Journal, April, 1876, the writer gave the results of investigations upon the nature of the gases evolved from a number of meteorites of both the iron and the stony classes, when exposed to a more or less elevated temperature. The stony meteorites examined were all of the more common type, containing a considerable percentage of nickeliferous iron, without any appreciable quantity of uncombined carbon. As is well known, however, among these bodies of the stony kind, the meteorites of Alais, Kold Bokkeveld, Kaba, and Orgueil, form a distinct class, differing from the rest in several particulars, and especially in containing considerable proportions of amorphous carbon, and a bituminous substance consisting of carbon combined with oxygen and hydrogen in such a way as to simulate organic products. They are further distinguished by containing only very small quantities of metallic iron. As it seemed of interest to determine whether the conclusions arrived at in the investigations previously described were applicable to the bodies of this peculiar class also, the work was continued, with the results given below. Several other points of importance, referred to in the previous paper, were investigated, and are discussed in subsequent paragraphs.

The material used for the determinations was a fragment of an excellent specimen of the Kold Bokkeveld meteorite in the cabinet of Yale College. It contains an inconsiderable propor-

tion of metallic iron, though this is not entirely absent, for, on filing away the surface, very minute particles may occasionally be seen. The analysis made by Harris* gives for the carbon 1·67 per cent, and for bituminous matters 0·25 per cent. As has been shown by Professor J. L. Smith,† the mineral constituents are not greatly different from those of the ordinary stony meteorites. The method employed for the evolution and collection of the gases was essentially the same as that described in previous papers, and need not be given in detail here. It is sufficient to mention that, as the meteorite gives off a large amount of water on being heated, the tube containing the substance was connected with the pump by a recurved tube, the bend of which was placed in a freezing mixture during the evolution of the gas, in order to collect the water and prevent it from entering the pump. This tube was sealed with a gas flame at the close of the experiment and the water retained for examination. The temperatures employed for driving off the gaseous contents were nearly the same as those of the previous experiments, being however slightly lower, in order to avoid as far as possible complication of the results by the action of the heat upon the bituminous matter. The results were as follows:

Kold Bokkeveld.

	CO_2.	CO.	CH_4.	H.	N.	Volumes.
300°–350°	87·34	5·08	5·93	trace?	1·65	7·45
500°	95·53	1·32	2·14	0·54?	0·47	17·78
Total.	93·11	2·42	3·25	0·38?	0·84	25·23

The volume of the gases obtained is much greater in this than in the previous determinations; but it will be seen that in its composition the gaseous mixture is similar to that derived from the ordinary stony meteorites, with the exception of the hydrogen, of which, if any was present, the quantity was so small as to make its determination a matter of some uncertainty. The percentage of carbon di-oxide is somewhat larger at the higher temperature than in the other cases, but the real difference here is less than it appears, as the increase in the quantity of hydrogen evolved at the higher temperatures from the specimens which contained metallic iron, produced a corresponding diminution in the percentage of the carbon di-oxide; neglecting this, the proportions would show a much closer correspondence. It seemed probable that, at least at the higher temperature, an appreciable quantity of some hydrocarbon of the olefiant series, that is, with more carbon atoms than are contained in marsh-gas, might be found. But both the analyses, and special tests

* C. Rammelsberg, Die chemische Natur der Meteoriten. Abhandl. der Königl. Akad. zu Berlin, 1870.

† This Journal, III, xi, p. 391.

of the gas with fuming sulphuric acid, showed that the quantity of such substances possibly present was too small to carry it beyond the range of the ordinary errors of observation. The bituminous substance would thus appear to have been simply volatilized by the degree of heat employed, and condensed again in the cooling-tube without decomposition. No attempt was made to collect it separately.

The amount of water driven off by the heat and collected in the cooled tube was found to be about ten per cent of the weight of the substance employed, but the determination was not entirely satisfactory. Faraday found for the water 6·5 per cent. Wöhler states that the powder dried at 120° lost 10·5 per cent more by stronger heat. Rammelsberg found that the total loss at a strong heat was 15·24 per cent, but this of course includes, besides the water, the gases evolved and the volatile bituminous substance, as well as some sulphur, which was observed to be volatilized. The water, on the application of the ordinary tests, gave distinct evidence of the presence of chlorine, and less certainly of sulphurous oxide, resembling in these respects that derived from other meteorites. A small quantity of a light yellowish substance was deposited in the cold part of the tube, which appeared to be sulphur, but was not specially examined.

The differences in the gaseous products obtained from meteorites of the different classes may be made more apparent by bringing together the results of analyses hitherto made. The following table gives the total percentage of the gases yielded by the different specimens, the first seven being irons, the remainder belonging to the stony class. It represents the composition of the total amount of gas given off up to incipient or low red heat, except in the first two instances where the temperature employed was much higher.

Iron meteorites.	CO_2.	CO.	CH_4.	H.	N.	Vol.	Observers.
Lenarto,	4·46	0·00	...	85·68	9·86	2·85	Graham.
Augusta Co., Va.,	9·75	38·33	...	35·83	16·09	3·17	Mallet.
Tazewell Co., Tenn.,	14·40	41·23	...	42·66	1·71	3·17	W.
Shingle Spr., Cal.,	13·64	12·47	...	68·81	5·08	0·97	W.
Texas,	8·59	14·62	...	76·79	0·00?	1·29	W.
Dickson Co., Tenn.,	13·30	15·30	...	71·40	0·00?	2·20	W.
Arva,	12·56	67·71	...	18·19	1·54	47·13	W.
Stony meteorites.							
Iowa Co.,	49·51	2·64	0·0?	43·93	3·92	2·50	W.
Guernsey Co., Ohio,	59·88	4·40	2·05	31·89	1·78	2·99	W.
Pultusk,	60·29	4·35	3·61	29·50	2·25	1·75	W.
Parnallee,	81·02	1·74	2·08	13·59	1·57	2·63	W.
Weston,	80·78	2·20	1·63	13·06	2·33	3·49	W.
Kold Bokkeveld,	93·11	2·42	3·25	0·38?	0·84	25·23	W.

In the case of the last of these meteorites the number given in the table does not express the whole volume of gas contained in it, as the experiment was discontinued before it ceased to be given off. A special determination made with a separate portion gave a little more than thirty volumes. The Arva meteorite also is exceptional, both as regards the volume of gas yielded by it, and with respect to the large volume of the carbonic oxide obtained. We are reminded, by this fact, of the Ovifak iron, from which Wöhler obtained, by heating it to redness in an iron tube, more than 100 volumes of gas which was found to be carbonic oxide mingled with a little carbon di-oxide.* He attributes it, however, to the action of the carbon upon some oxygen compound, and the mass was found to contain a large quantity of magnetic oxide of iron. Doubtless the result was affected by the employment of the iron tube, which would rapidly reduce the carbon di-oxide at such a temperature. Berthelot, who examined another portion, at M. Daubreé's request, obtained by slow calcination in a tube of Bohemian glass a large volume of gas, the precise amount of which is not stated, consisting chiefly of the two oxides of carbon in nearly equal quantities.† The celestial origin of the Ovifak iron is very doubtful, however, and its composition is different from that of the Arva meteorite, in which no oxygen compounds were detected.

A few words need to be said with reference to the volumes quoted in the case of the Tennessee, Texas, and Arva irons. In an article published in this Journal, for April, 1875, giving an account of a spectroscopic examination of the gases from these bodies, it was stated that the volumes were as follows: Tennessee, 4·69; Texas, 4·75; Arva, 44+, whereas the volumes as determined in the subsequent investigations by actual measurement were 3·17, 1·29, and 47·13, respectively, as given in the table. The discrepancy is due to the fact that the former numbers were calculated from the change in the reading of the gauge of the air-pump on evolution of the gas, and were not corrected for the small amount of water vapor present. Where the quantity of gas was small the error from this source was considerable, and the result would have only the value of a rough estimate. In the case of the Arva iron, where the volume of the gas was much larger, the inaccuracy was not serious, and the volume corresponds much more nearly with the true result as obtained from measurement. In the later determination of the volume of gas from the Texas iron, moreover, the metal was in rather coarse fragments, and the evolution of gas from it was not as complete as in the previous case. That the amount of gas obtainable from this iron

* Pogg. Ann. 146, p. 297. † Comptes Rendus, lxxiv, 1545.

should approximate to that obtained from the Tennessee specimen, if the trial were made with finely pulverized metal, is clearly indicated by the results of the earlier experiments.

The necessity for the precautions mentioned in the previous paper respecting the degree of heat employed and the time of its application, was well shown in the repetition of the experiments with the Iowa meteorite. The reducing action of the metallic iron upon the carbon di-oxide, though not very apparent at comparatively moderate temperatures, becomes considerable as the temperature rises, and in some of the experiments where the heat was carried nearly to redness and prolonged beyond what was necessary for the evolution of the larger part of the gas, it was found that the amount of carbonic oxide was very variable, in one instance reaching to 12 or 13 per cent. This explains also the larger amount of this gas obtained in the preliminary examination of last year where the analysis gave 14 per cent, as no special attention was at that time given to this source of error. It is also clearly shown by the following experiment with a portion of the Weston meteorite. After the gas had been driven off from this by a red heat, pure, dry carbon di-oxide was admitted into the pump, and the tube heated nearly to redness for about half an hour. On pumping out some of the gas and analyzing it, it was found that nearly twenty per cent of it had been converted into carbonic oxide. Although great care was taken in all the subsequent work to avoid this source of inaccuracy as completely as possible, the percentages of this gas obtained at the higher temperatures are less certainly to be depended upon than the others. The amount of marsh-gas obtained also shows a certain correspondence with that of the carbonic oxide, as if, possibly, in the reaction by which the carbon di-oxide was broken up by the iron, a portion of the carbon combined with the hydrogen present to form marsh-gas, a supposition which is not without warrant from the conclusions of other observers.* But though some degree of uncertainty may attach to the numbers given for the higher temperatures, the fact that, with all the precautions observed in the experiments, the gases were found to be present in small quantities even at the lowest temperatures at which examination was made, renders it probable that the results are not far from the truth, and that carbonic oxide and marsh-gas are really to be reckoned among the gaseous contents of the stony meteorites, and that the same cause which produced the one in greater or less quantity had a similar effect upon the other.

Among the questions discussed in the previous paper, was the manner of the occurrence of the carbon di-oxide. This has

* Watts's Dict. of Chem.

been subjected to further examination, with the result of modifying somewhat the conclusions there arrived at. That it has been derived from the atmosphere by absorption subsequently to the fall of the body is improbable, for not only did the re-examination of the Iowa meteorite show a loss rather than gain with the lapse of time, but also there would seem to be little reason for a selective action of the mass, which would enable it to take up this gas in preference to the other atmospheric constituents, unless it were the fact of the feebly acid character of the carbon di-oxide, as in the presence of, or combined with. water. But in this case the carbonates formed by combination with the oxides present in meteoric masses, would be very stable compounds, and quite incapable of decomposition at the low temperatures employed.

The explanation was suggested in the earlier papers that the gas was condensed upon the finer particles of the metallic iron, as well as absorbed within it. With a view to test the correctness of this supposition, a special set of experiments was undertaken. A quantity of the substance of the Iowa meteorite was reduced to fine powder, and the iron extracted from it with a magnet, and kept by itself. The grains of iron were then rubbed repeatedly in an agate mortar to free them as completely as possible from the adhering stone, from which they were separated as before, the residue of the powder being added to that left by the first operations. The material was thus divided into two portions, one of which consisted chiefly of the stony matter, the other principally of the iron. For a third portion pieces of the meteorite were simply broken into small fragments, and not pulverized. Each portion was placed in a clean tube, and in its turn attached to the pump for examination, care being taken to subject each, as nearly as was possible, to the same degree of heat, and for the same length of time. The highest temperature employed was below that of red heat. The following were the results obtained :

	CO_2 and CO.	H.	N.		Volumes.
Powder,	66·96	30·96	2·08	0·97	1·48
Iron,	38·72	59·38	1·90	0·51	
Fragments,	48·07	50·93	1·00		1·87

Although, from the nature of the case, no very precise result could be expected from this mode of experiment, inasmuch as it was impossible either to separate the iron entirely from the mineral portion, or to free the iron completely from the stony matrix, the numbers above given indicate clearly that the stony portion yields a considerable portion of the gas given off at the temperature employed, and that this contains a larger proportion of the carbon oxides than that obtained from the iron, which, on the other hand, is richer in hydrogen. The product

of the stony fragments is, in its composition, approximately a mean between the two others, as was to be expected, but it will be seen that the volume obtained was somewhat larger, showing that a portion of the gas was lost in the process of pulverization. These facts would seem to indicate that, while a portion of the gas may be condensed upon the fine particles of the iron as at first conjectured, a large part of the carbon di-oxide, and possibly also of the water, carbonic oxide, and other gases, is mechanically imprisoned in the substance of the meteorite. Now Mr. Sorby has shown* that the meteorites of Aussun and Parnallee, when examined in thin sections under the microscope, contain numerous small cavities filled with gas, similar to those which have been observed in many terrestrial minerals. It will be noticed that the Parnallee meteorite was one of those examined by the writer, and found to yield 2·63 volumes of gas on the application of heat.

The occurrence of carbon di-oxide in cavities of minerals, under a pressure so great as to cause it to be in the liquid condition, as also associated with water, has been often observed, and has been quite recently proved in an ingenious and satisfactory manner, by Mr. Hartley,† for a large number of different minerals. Similar gas-cavities have been shown also to exist in many eruptive or volcanic rocks, for examples of which we need only to refer to Mr. Sorby's and Mr. J. C. Ward's papers in the Quarterly Journal of the Geological Society, and to other memoirs published elsewhere. The actual extraction and chemical examination of the gaseous contents of these bodies appears to have attracted little attention thus far, though they might lead to results of great interest and importance. Some incomplete experiments by the writer may be mentioned here, as illustrations, though but little weight is attached to them as quantitative determinations. A quantity of pulverized trap-rock was subjected to a heat which was raised to incipient redness, the examination being conducted by the same method as that employed upon the meteorites. The mineral gave off about three-fourths of its volume of mixed gases, which were found to contain about 13 per cent of carbon di-oxide, the residue being chiefly hydrogen. Another specimen of trap containing small nodules of anorthite, was examined, at the request of Mr. G. W. Hawes, who had observed gas-cavities in a thin section of the mineral prepared for microscopic examination. This gave off somewhat more than its own volume of gas, which was found to contain some 24 per cent of carbon di-oxide. The gas in these cases was not given off as readily as from the meteorites, and was evolved rather suddenly as a temperature approaching red-heat was reached. If it should appear improbable that the large

* Proc. Royal Soc., June 16, 1864.
† Chem. News, June 9, 1876, p. 237.

amount of gas contained in the Kold Bokkeveld specimen could be retained in this way, it may be suggested that the amorphous carbon contained in it is a substance peculiarly fitted to absorb and retain large volumes of gas. These results would seem rather to assimilate the stony meteorites to terrestrial rocks of volcanic origin, than to place them in a different category, and to strengthen the evidence that they are themselves the product of igneous action, though modified profoundly in some respects in their structure, by the influence of other forces, and the circumstances of their formation. The supposition of the imprisonment of the gas in the stony substance would also serve to explain why the water, which can not be separated by a temperature of 100°, continues to be given off even at the highest temperatures employed, as has often been observed in experiments with meteorites.

It has been pointed out by astronomers that on arranging the mean distances of the asteroids in a series, there are found to be certain gaps in the list, as if some members were wanting. Now it is further found that the periodic times of these missing bodies stand in a simple relation to the time of Jupiter's revolution, and in such a way that his continued action upon them would accumulate the perturbative effects, tending to throw their orbits into eccentric forms. Such of the bodies as were caused to move in very narrow orbits, with shortened period, would be exposed to very great vicissitudes of temperature, and during the part of the orbit near the sun not only would the change of temperature be comparatively rapid but the actual degree of temperature reached would be very considerable, especially considering the fact that these bodies are of too small mass to permit them to retain an atmosphere of any appreciable amount. It is not difficult to see that these great changes of temperature in a mass of considerable absorptive and low conducting power must give rise to powerful stresses, and that under the intense action of the sun near the perihelion the action may be sufficiently energetic to cause the splitting up of the bodies themselves. The disruptive action requisite to separate a mass from the principal body entirely, and so as not to return, would be less as the mass of the body is smaller, and would, for a mass no larger than some of the asteroids, be quite within the range of possibility. The body would thus be subject to a continuous process of disintegration in its successive revolutions, and must end in being broken up into a swarm of fragments which would gradually be distributed over the entire orbit. Such an action appears to be really going on in some of the comets, and moreover the orbits of several of them are coincident with those of great meteoric streams, in which the process of disaggregation has already gone very far. Now, of the comets of short period a considerable number are grouped

with their orbits in such a relation to that of Jupiter as to suggest the possibility of their derivation from the asteroids. Similar considerations also apply to the group of comets associated with the orbit of Neptune, the existence of which suggests the question whether there may not be another group of asteroids, exterior to this body, yet remaining to be discovered. But without assuming the asteroidal origin of these comets, the effects of solar heat just described may be safely predicated of them, as well as of other comets or meteoric masses revolving in excentric orbits.

This process of disintegration, in the earlier stages of the history of one of these bodies, would constantly present fresh surfaces for the action of the sun's rays, which must cause the evolution of large volumes of gas, and the rifts and fissures produced by the cooling at aphelion would allow the gas contained in the interior of the body to stream off under comparatively little increase of temperature. This gaseous matter, expanding into empty space and streaming off, forms the tail of the comet, which is driven away from the sun's direction by some repellant force possibly due to electrical action. That the amount of gaseous substance furnished by such a body should be sufficient to form a luminous train of the immense extent often observed in comets need not appear incredible, if we reflect that of a substance like the Kold Bokkeveld meteorite every cubic mile would furnish thirty cubic miles of gas at the pressure of the terrestrial atmosphere, and that this in space would be speedily expanded to enormous dimensions, before it would cease to be capable of transmitting electric discharges, or to be visible by reflected sunlight. As the masses of some of the comets have approached planetary dimensions there is no difficulty in accounting for the enormous trains some of them have exhibited. Moreover there is reason for believing that the meteorites which reach the earth are the spent fragments, as it were, which have already parted with a considerable portion of their gaseous constituents by the long continued action of the sun as above described, so that the amount of gas contained in some of these celestial bodies may be even much larger than that we observe in actual meteorites. We may also take into account the not inconsiderable amount of water contained in these bodies, to say nothing of the volatile carbonaceous matters which are present in some of them.

Besides the relations mentioned above, may be cited the near correspondence of the average density of the stony meteorites with the calculated density of the asteroids, which, though possibly accidental, is certainly suggestive of a community or similarity of origin.

Additional and most striking testimony to the real connection

of the meteorites and comets is afforded by the close resemblance of the spectrum of the gas obtained from the stony meteorites to the spectra of those comets which have thus far been observed.

Many observations respecting this point were made upon the gases collected from the various meteorites examined, in the course of the investigations which have been described. Vacuum-tubes of the form usually employed in spectroscopic work were attached to the pump and filled by the meteoritic gases as they were evolved. After the latter had been pumped out for the most part into the collecting tube, a freezing mixture was applied to one of the tubes of the pump and allowed to remain until the watery vapor was condensed, thus rendering the gas in the vacuum-tube very nearly free from moisture. As the vapor of mercury is always shown by spectroscopic examination to be present in tubes filled in this way by the use of a mercury-pump, small pellets of clean gold foil were previously placed in the tubes, in order to absorb the metal. This proved to be quite effectual in some cases, in others only partially so. The tubes, having now been sufficiently exhausted by the continued action of the pump, were removed, sealed, marked, and preserved for examination.

On passing the discharge of an induction coil through these tubes when placed before the slit of a spectroscope, a spectrum is seen, which varies with the conditions. That from the capillary portion of the tube shows the hydrogen lines brilliantly, together with the bands due to carbon compounds. In the wide part, however, the hydrogen lines are entirely absent, only the carbon bands being visible. When the illumination is sufficiently strong these are five in number, all sharp at the least refrangible edge, and fading gradually away at the other. When the slit is narrowed, or the tube removed to a greater distance so as to diminish the intensity of the light, only three remain visible, namely, one beginning in the yellowish-green, one in the green, and another in the greenish-blue. Of these the middle one is by far the brightest, and when the light is very much enfeebled remains visible after the others have disappeared. Of the latter, the one in the greenish-blue is brighter than the other. A resemblance to the spectra of the comets is apparent at a glance, not only in the positions, but also in the form and relative brightness of the bands. A closer comparison however shows a marked difference in their breadth, the cometary bands, as represented by various observers, covering a considerably greater space. There appeared also to be a want of exact coincidence in their positions. For the first two the difference was not greater than the discrepancies of the results given for different comets, and the bands agreed very well with some of the observations. The third band showed a greater divergence.

As the greater breadth of the cometary bands indicates a density of the cometic gases greater than that in the tubes examined, an experiment was made, as follows, for the purpose of observing the effect of increasing the density of the gas. A glass tube, having an internal caliber of about one centimeter and some twenty centimeters in length, was closed at one end, and through the sides were inserted two platinum wires, at points near the middle of the tube, the inner ends of the wires being in its axis and separated by an interval of about one centimeter. Small fragments of the Kold Bokkeveld meteorite were dropped into the tube and shaken down into the closed end. The upper end was now drawn out to a narrow neck, and the whole attached to the pump. After exhausting the air, the neck was sealed, the tube withdrawn, and supported in a vertical position so that the interval between the wires was before the slit of the spectroscope, the end containing the meteorite being below. By means of wires connecting the platinum points with an induction coil, sparks were passed across the interval, and when the lower end of the tube was gently heated, the characteristic spectrum of the gas evolved became visible. At first it was very similar to that which had been observed previously, but as the heat was increased, and the pressure of the gas became greater, the bands were seen to widen out, until they at length fully equalled in breadth those of the comets, and finally they showed a tendency to run together. In the order of their relative intensity there was no appreciable change.

The slight disagreement in the positions of the first two bands with the reported observations of cometary spectra is readily explained when we consider that for the latter a rather wide slit is necessary in order that they may be distinctly seen. If the object viewed were a sharp fine line, the effect of opening the slit would be merely to increase its breadth without affecting the sharpness of the edges. It is easy to see however that a band, though with a narrow slit the edge were sharp and brighter than the other parts, would have its point of maximum brightness removed toward the middle of its breadth, and the farther as the opening were greater. The effect of this would be that a faint band would appear hazy at the edge, and the tendency would be to displace its apparent position towards the brightest point. Further, the measured position of the edge would be affected by the change of place of the movable edge of the slit. A simple experiment with the tube showed that the alterations from these two sources were sufficient to account for the apparent want of agreement in the positions of the bands, and also to explain some of the discrepancies in the results of different observers, as to the posi-

tion of the cometary bands, especially when regard is paid to the faintness of the light and the consequent difficulty of precise determination. Measurements of the first two bands, with the slit rather wide and the intensity of the light sufficiently diminished, were found to coincide very satisfactorily with the best recorded observations upon the corresponding bands in the spectra of comets. For the third band the result was less satisfactory, as it appears to be somewhat less refrangible than its cometary analogue, as determined by the majority of observations of the latter, though it agrees very well with some of them. Not improbably, however, the hydrocarbons existing in small quantities in some of the meteorites may be present in the comets in sufficient amount to modify their spectra somewhat.

Yale College, July 28, 1876.

ART. XXII.—*Schœnbein's Test for Nitrates;* by F. H. STORER, Professor of Agricultural Chemistry in Harvard University.

IN his important paper on the Behavior of Ozone towards Water and Nitrogen, Carius* remarks incidentally that he has not found the iodo-starch test for nitrates (employed in conjunction with zinc, as the reducing agent) a specially delicate one.

It is obvious that this test for nitrates cannot in the nature of things compare in delicacy with the similar test for nitrites, where the iodo-starch is added directly to the suspected liquid, after mere acidulation. A much smaller quantity of nitrite than of nitrate can always be detected by the above mentioned test, since the zinc, or other reducing agent, which is made to act upon the nitrate in order that the iodo-starch reaction may occur, does not in any case change the whole of the nitrate into a nitrite and no other nitrogenous product. The zinc may fail, upon the one hand, to reduce the whole of the nitrate, while upon the other its action may go too far, so that a part of the nitrite, formed at first, through reduction of the nitrate, may be reduced in its turn and removed from the field of action. Some of the nitrate is always changed, withal, to an ammonium salt and so destroyed in so far as the power of reacting upon iodo-starch is concerned.

These considerations have often been urged, and they are undoubtedly familiar to most chemists. But in the lack of a better, the iodo-starch test for nitrates has come into very general use and has been held in high estimation. The remark of Carius must have struck scores of chemists, as it did myself,

* Annalen der Chemie, 1874, clxxiv, 14, note.

as extraordinary and hardly credible. It was neither consistent with Schœnbein's statement as to the delicacy of the test nor with the reputation which the test had acquired. I have thus been led to examine the matter somewhat attentively and to subject the test anew to critical study. It appears from this examination that the lack of delicacy observed by Carius was due to the kind of manipulation employed by him, and that while his statement is doubtless literally correct it fails to convey a just idea of the much higher degree of delicacy which is readily obtainable by applying the test in a somewhat different way.

Two methods of using the test were described by Schœnbein,* viz: 1st, To add dilute sulphuric acid and iodo-starch paste directly to the nitrate solution and to stir the mixture with a zinc rod; or, 2d, and better, as we must infer from Schœnbein's statement, to reduce the neutral solution of the nitrate in the first place, by means of zinc or cadmium, thereafter to acidulate it with dilute sulphuric acid, and finally to add the iodo-starch paste. Both of these modifications have come into general use, but the second has been applied perhaps even more frequently than the first in cases where very small amounts of nitrates were to be sought for. It is in fact more delicate than the first method. Carius, however, in the experiments above referred to, employed the first modification and not the second.

For my own part, I find that the chief objection to the iodo-starch test for nitrates is by no means a lack of delicacy. The fatal defect of the test, as hitherto applied, is to be found in the fact that mere water, which is absolutely free from any contamination of nitrates or nitrites, on being treated with zinc or cadmium, as if to test it for a nitrate, will react upon iodo-starch precisely as if a trace of some nitrate had been dissolved in the water.

The explanation of this behavior is not far to seek. The coloration of the iodo-starch is caused by peroxide of hydrogen which has been formed in the water by the action of the metal, according to the familiar experiment of Schœnbein† in which peroxide of hydrogen is prepared by shaking zinc-amalgam in water and air.‡

* See for example, his paper in Fresenius's Zeitschrift analyt. Chemie, 1862, i, pp. 14, 15.

† Poggendorff's Annalen, 1861, cxii, 288.

‡ Schœnbein has himself shown (Journal für prakt. Chemie, 1861, lxxxiv, 206) that peroxide of hydrogen is formed simultaneously with a nitrite, when the aqueous solution of a nitrate is treated with zinc or cadmium, as a preliminary to the application of the iodo-starch test, but he seems to have completely overlooked the fact that the presence of the peroxide would preclude the application of his test for nitrites, in cases where the solution to be examined contained only a small quantity of the nitrate.

The amount of peroxide of hydrogen that is formed in the limited volume of liquid used, and under the conditions which ordinarily obtain when testing for a nitrate, is undoubtedly very small, but it is nevertheless sufficient to give a perfectly distinct reaction with acidulated iodo-zinc-starch solution. This reaction is far too strong to admit of its being neglected, subtracted, or allowed for, when searching for traces of nitrates. Hence it happens, that in highly dilute solutions of nitrate of potash it is impossible to detect the nitrate by means of iodo-starch as ordinarily applied, not because the products of the reduction of the nitrate by zinc, or the like, cease to act upon the iodo-starch, but because the reaction produced by these products is identical with that of the peroxide of hydrogen that is formed simultaneously with them, and which would be formed just as well in pure water totally devoid of nitrates.

Whenever the degree of coloration of the iodo-starch obtained, in testing for a nitrate according to Schœnbein's method, is less intense than the tint obtainable from 0·0001 gram N_2O_5 (=0·000187 gram KNO_3) in 50 c.c. water it is difficult to decide whether the coloration may not be wholly due to peroxide of hydrogen. It is easy, at all events, to obtain as much peroxide of hydrogen by boiling cadmium, zinc or amalgamated zinc with mere water, as will give a reaction with acidulated iodo-zinc-starch equal to that obtainable from 0·00005 gram N_2O_5 or perhaps even more. The following experiments will illustrate this point.

A. To 50 c.c. of pure water 0·00005 gram N_2O_5 (in the form of 0·0000936 gram of nitrate of potash) was added, the mixture was boiled five minutes with a piece of cadmium, in a small flask, then cooled, transferred to a porcelain capsule, acidulated and tested with iodo-zinc-starch.

B. The same experiment was repeated with pure water to which no nitrate had been added.

C. Same as A., with the exception that zinc was used instead of cadmium.

D. Same as B., with the exception that zinc was used instead of cadmium.

The four capsules were placed side by side under a darkened bell glass and left to stand over night. On examination it appeared that while the contents of capsules B, C and D seemed to be of one and the same depth of color, the contents of capsule A were distinctly lighter colored than those of either of the other dishes. These experiments were simultaneous, and care was taken that they should be strictly comparable one with another. Each experiment was conducted as if a nitrate were being tested for. Equal surfaces of metal, as nearly as might be, were exposed to the action of the liquids, in each instance.

Repetitions of these tests gave similar or analogous results Sometimes the contents of one capsule in the series would be more or less strongly colored than the rest and at other times another, but everything went to show that by this method of testing. traces of nitrates cannot be distinguished from the peroxide of hydrogen that is naturally formed in the liquid under examination. So too, when amalgamated zinc was used instead of the simple zinc or cadmium. It is true, as Schœnbein * has said, that water which contains only $\frac{1}{100000}$ of nitrate of potash will color iodo-starch blue, after having been shaken or boiled with bits of amalgamated zinc, filtered, and acidulated with sulphuric acid; but since water that is absolutely free from nitrates will do almost precisely the same thing when similarly treated, the statement is of no value either as regards the delicacy of the test, or the limit of its applicability.

Proof that the cause of the reaction in the water free from nitrates is really due to the presence of peroxide of hydrogen is readily obtained on testing the neutral liquid for that substance, with a drop or two of a weak solution of ferrous sulphate † and the solution of iodo-zinc-starch. The characteristic blue coloration of the iodo-starch will quickly appear when pure water that has been boiled with cadmium or with zinc is subjected to this test, while no reaction is obtained, even after the lapse of many hours, when pure water that has not been in contact with a metal is similarly treated.

With pure water these results are constant and invariable, but it is noteworthy that on testing in this way, samples of water taken from wells, and of rain water taken respectively from a brick and from a leaden cistern, no reaction for peroxide of hydrogen was obtained after simple boiling for five minutes with the cadmium, though on boiling with cadmium and then leaving the liquid to stand upon the metal for twenty-four hours a reaction for the peroxide was finally obtained with the rain water. So too when the pure water was tested in a somewhat different way by mixing it directly with the solutions of iodo-zinc-starch and sulphate of iron and ammonia, and placing a piece of cadmium in the mixture, the blue coloration soon appeared, while no such coloration was observed when samples of rain or well water were tested in this way; far from becoming blue, the liquids soon acquired a rusty color, as if from oxidation of the iron salt.

Care was taken to control the peroxide reactions by apply-

* Zeitschrift analyt. Chemie, 1862, i, 15.

† Or instead of simple ferrous sulphate, the double sulphate of protoxide of iron and ammonia may be used with advantage, as was suggested by Struve, Fresenius's Zeitschrift analyt. Chemie, 1869, viii, 319. Most of the tests described in the text were made with this double salt. Two or three drops of a $\frac{1}{1000}$ normal solution of it were ordinarily used.

ing the test (ammonium-ferrous sulphate and iodo-zinc-starch) to acidulated water, that had not been in contact with cadmium or zinc, to acidulated and to neutral solutions of pure nitrate of potash, to neutral solutions of nitrite of soda, all made with pure water, and to the distillate from a solution of nitrite of soda that had been boiled with dilute sulphuric acid. But no trace of blue coloration was observed in either instance.

Corroborative evidence of the presence of peroxide of hydrogen in the water that had been boiled with cadmium was obtained as follows: Two portions, each of 100 c.c., of pure water, were taken. To one portion two hundredths of a milligram of nitrous acid was added, in the form of nitrite of soda, together with 2 c.c. of dilute sulphuric acid (1:4) and the mixture was boiled for ten minutes in order to expel the nitrous acid. The other portion was boiled with cadmium, as if it were to be tested for a nitrate, the cadmium was removed, the liquid was mixed with 2 c.c. of the dilute acid and then boiled for ten minutes. Each portion was finally tested, when cold, with iodo-zinc-starch. The second portion, viz: the one to which no nitrite had been added, speedily gave a reaction, but the first portion did not. After standing twelve hours in the dark, the first portion remained colorless, while the second portion was distinctly blue. In a word, the nitrous acid known to have been present in the first portion had been completely expelled by the boiling, while much of the peroxide of hydrogen in the second portion had remained intact.

The fact that highly dilute aqueous solutions of peroxide of hydrogen suffer but little decomposition at the temperature of boiling has often been insisted upon;* but less attention seems to have been paid to the equally important fact† that some of the peroxide goes forward, as such, with the vapor of water, and may be detected in the distillate. This volatility of the peroxide is a point of no little significance for the analyst, since it makes it very much more difficult than would otherwise be the case to detect traces of nitrites in solutions suspected to contain them, as well as the peroxide. Contrary to the opinion expressed by Plugge‡ it would be altogether useless in delicate experiments to apply, in the presence of peroxide of hydrogen, that method of testing for nitrites which depends upon the volatility of nitrous acid, viz: the distillation of the nitrite solution with a dilute acid and subsequent testing, with iodo-starch plus acid, for nitrous acid in the distillate. The following experiments will illustrate the importance of this consideration. Two portions of pure water, each of 250 c.c., were taken, and one was distilled directly with

* Compare Gmelin-Kraut's Handbuch der Chemie, 1872, i (2te Abth.), p. 58.

† First recognized, I believe, by Schœnbein. See Will's Jahresbericht, 1866, p. 105.

‡ Fresenius's Zeitschrift analyt. Chemie, 1875, xiv, 141.

acetic acid while the other was boiled with cadmium for five minutes and thereafter distilled with acetic acid, pains being taken to make the two experiments alike in all other respects. The first 50 c.c. of distillate were collected in each instance and tested with iodo-zinc starch, after acidulation. No reaction was obtained in the distillate from the mere water and acetic acid, while the distillate from the water that had been boiled upon cadmium became colored in less than half an hour. Repetitions of this experiment gave similar results.

That only a part of the peroxide goes forward with the steam will be seen from the following trials:—Two separate 250 c.c. portions of pure water that had just been distilled off from a flask containing a mixture of zinc and spongy copper were boiled with cadmium, and a part of each of the liquids was tested directly with iodo-zinc starch plus acid, while the remainders were distilled with acetic acid and the first 50 c.c. of distillate was subjected to the test in each instance. In both trials the portions tested directly gave a stronger coloration than was obtained in either of the distillates. In order to be sure that the acetic acid had no improper influence on these reactions, several portions of pure water were distilled with the acetic acid for a time, a fresh portion of the acetic acid was then added and the next 50 c.c. of distillate was tested with iodo-zinc starch plus acid, but no reactions were obtained, although the mixtures were allowed to stand twenty-four hours after the application of the test.

It may be mentioned in this connection that the tendency of peroxide of hydrogen to be transported with the vapor of water may perhaps afford the true explanation of the cause of the presence of the peroxide in some of the solutions examined by Meissner in his Untersuchungen über Sauerstoff, Hannover, 1863, pp. 94–110. Such transportation of the peroxide may account moreover for the presence of this substance in the outer or water tube of Schœnbein's and Meissner's (op. cit., p. 74) earlier experiments on the making of peroxide of hydrogen from peroxide of barium and sulphuric acid, without need of supposing that the "antozone" of these chemists had any part in the reaction.

With regard to the delicacy of the iodo-starch test for nitrates, supposing there were no interference from peroxide of hydrogen, it appears, as has been stated above, that that method of procedure in which the nitrate is reduced by itself, as a separate, preliminary step, before the acidulation of the liquor or the addition of the iodo-starch, is decidedly preferable to the other system of adding the iodo-starch, the acid, and the reducing agent all at once to the nitrate solution. As Goppelsrœder*

* Poggendorff's Annalen, 1862, cxv, 128.

has remarked, it seems to be immaterial whether the nitrate solution be boiled for a few moments with the cadmium or zinc, or left to stand for some hours in the cold in contact with one of these metals; though the boiling will usually be found more convenient in practice.

It has been customary hitherto, in this laboratory, to proceed as follows, when testing for nitrates by Schœnbein's process: 100 c. c. of the suspected liquid were put in a small glass flask, together with bits of metallic cadmium and boiled for five minutes. When the liquid had become cold half of it was transferred to a small porcelain dish, one c. c. of dilute sulphuric acid* was added to it, and finally, two c. c. of iodo-zinc-starch solution.† The capsule, with its contents, was then placed under a darkened bell-glass and examined at stated intervals. Tested in this way, a solution of nitrate of potash, containing

* The dilute sulphuric acid is prepared by mixing one volume of oil of vitriol with three volumes of pure water, boiling the mixture for an hour, and finally adding enough pure water to replace that which has evaporated.

† The solution of iodo-zinc-starch is prepared as follows, after Kubel-Tiemann, "Anleitung zur Untersuchung von Wasser," Braunschweig, 1874, p. 140: Rub 4 grams of starch in a porcelain mortar with a little water, and pour the smooth, milky liquid, little by little, into a boiling solution of 20 grams pure commercial chloride of zinc in 100 c. c. of distilled water. Continue to boil the mixture until as much of the starch as possible has dissolved, and the liquid has become almost clear, taking care meanwhile to replace the water that evaporates. Dilute with distilled water; add 2 grams of pure, dry, commercial iodide of zinc; bring the volume of the liquid to a litre, and pour it into a tall cylinder, to settle. After several days, decant the clear liquid and keep it in the dark in well-closed bottles.

Pure water is obtained as follows: Enough crystallized permanganate of potash is dissolved in rain-water to color the liquid strongly; the mixture is left to stand for 24 hours, and then transferred to a copper still. A lump of lime is added and the mixture is distilled slowly, the first fractions of distillate being rejected. The rest of the distillate is redistilled in a glass flask, upon lime, and the new distillate is rejected until it ceases to show ammonia when tested with Nessler's reagent. Such water is free from ammonia and from nitrates, and when tested for nitrites with iodo-zinc-starch, plus acid, it will not show any trace of coloration at the end of an hour, and will seldom show any appreciable tinge of color when the mixture is left to stand over night, though on standing for 24 hours a faint shade of color will usually appear. I have commonly attributed this tendency to give a reaction to the presence of an infinitesimal trace of nitrite, but it is not impossible that it may be due to peroxide of hydrogen that has been formed by means of the copper of the still. It would undoubtedly be better, when possible, to perform all the distillations in glass vessels. However that may be, such water is abundantly pure enough for the purposes of this research. For cases where absolute purity is essential, water that will not give any reaction for nitrites may be prepared, by acidulating with acid sulphate of soda the pure water obtained as above (from glass vessels) and redistilling it in a glass flask. Free nitrous acid being readily volatile will go forward in the first portions of distillate from the acidulated water, so that, by rejecting a considerable fraction of the distillate at first and saving the water that comes over later, it is no very difficult matter to obtain water that is perfectly free from all three of the nitrogen compounds now in question as well as from peroxide of hydrogen.

Most well waters it should be said, are, if anything, rather better than rain-water for preparing a pure product.

By making the mixture of permanganate and water alkaline with lime instead of a caustic alkali, the nitrous compounds which almost always contaminate the latter are avoided.

0·0005 grm. N_2O_5 in 50 c. c. water, gave an immediate coloration on being mixed with iodo-zinc-starch plus acid, after having been boiled for five minutes upon cadmium; with a solution containing 0·0002 grm. N_2O_5 the blue coloration appeared about 5 minutes after the addition of the iodo-starch, and with a solution containing 0·0001 grm. N_2O_5 the color began to appear in about 8 minutes. The last named quantity indicates very nearly the limit of applicability of the test, since the degree of coloration derivable from an amount of the nitrate any smaller than this, could hardly be distinguished from that due to the peroxide of hydrogen that is obtained on boiling pure water upon cadmium or zinc. It is true that the coloration caused by the products of the reduction of a nitrate generally appears rather more speedily than the coloration produced by peroxide of hydrogen, but since the reaction of the peroxide often begins to show ten or fifteen minutes after the addition of the iodo-zinc-starch and acid, and sometimes even sooner, no dependence can be placed upon mere rapidity in the appearance of the coloration, as a means of distinguishing the nitrate from the peroxide. In case the mixtures are left to stand over night, or for a number of hours, after the iodo-starch has been added, this seeming advantage in favor of the nitrate solutions disappears, for after long standing the coloration due to peroxide of hydrogen is often as deep as that obtained from 0·00005 grm. N_2O_5, and the difference between this tint and that obtained from 0·0001 is by no means large enough to permit of distinguishing the one from the other with any certainty.

Results very different from the foregoing were obtained when 50 c.c. of the pure nitrate solution, mixed directly with two drops of the dilute acid and 2 c.c. of the iodo-zinc-starch solution, were left to stand in contact with a rod of zinc, according to the method employed by Carius.* On proceeding in this way, a solution containing 0·01 grm. of N_2O_5 (=0·01872 grm. KNO_3), in 50 c.c. of water gave a reaction almost immediately when the zinc was added; and a solution containing 0·005 grm. N_2O_5 (=0·00936 grm. KNO_3) began to show a blue coloration at the lower end of the zinc rod in a few minutes, while in a solution containing 0·002 grm. N_2O_5 (=0·00374 grm. KNO_3) no coloration could be perceived even after the lapse of two hours, though the liquid was examined at frequent intervals. On repeating this trial with 0·002 grm. N_2O_5 a similar result was obtained. 0·003 grm. N_2O_5 (=0·005616 grm. KNO_3) in 50 c.c. water gave a very slight coloration at the lower end of the zinc rod after a comparatively short time. Trials similar to the above, in which amalgamated zinc was used instead of simple zinc, gave

* Annalen der Chemie, 1874, clxxiv, 14.

no better results, but rather worse on the whole. Rods of cadmium appeared to be somewhat preferable to those of zinc, though not much.

It will be observed that the results of these tests are even less favorable than those obtained by Carius, since this chemist puts the limit of delicacy at 0·0015 grm. KNO_3 in 50 c.c. water. The following experiments moreover go to show that when the test is used in this manner the presence of trifling impurities in the solution to be examined may interfere with the reaction very decidedly and render the negative indications of the test untrustworthy even at the comparatively low degree of delicacy above mentioned. Thus, on repeating some of the foregoing trials and using rain-water to dissolve the nitrate, instead of the pure water previously used (see page 182, note) less favorable results were obtained. A solution of the nitrate equal to 0·005 grm N_2O_5, in 50 c.c. cistern water gave no reaction with the iodo-zinc-starch in the course of an hour. On repeating the trial with cistern-water that had just been boiled, a slight reaction was obtained, but the blue color instead of increasing faded away after a time and disappeared. The proportion of acid employed to acidulate the mixture is not without influence upon the delicacy of the test, and it may well be that in order to the best results a larger amount of acid is required than was used in the foregoing trials. The small quantity of the acid actually taken was chosen in order to conform to Carius's injunction that "the addition of but little acid is a condition of success." But it appeared once on repeating the trial with the nitrate solution, in pure water, that contained 0·005 grm. N_2O_5 in 50 c.c., that while no coloration of the iodo-starch had appeared after some time so long as only two drops of sulphuric acid had been added, the reaction soon set in on the addition of two more drops of the acid.

The defect of the usual method of testing for nitrates having been made apparent, I have naturally endeavored to discover some better method of procedure which, while preserving all the delicacy of the test, should permit its general application. Casting about for some means of reducing nitrates to nitrites which should not at the same time occasion the formation of peroxide of hydrogen, I have finally hit upon the simple device of boiling the nitrate with metallic cadmium in water that is slightly acidulated, instead of operating with neutral solutions, as has hitherto been recommended. Contrary to what might have been inferred from what has been published hitherto, and from what is known of the action of acidulated water upon metals in the cold, no peroxide of hydrogen is formed when water slightly acidulated with sulphuric acid is boiled upon metallic cadmium; and since the reduction of

nitrates to nitrites by means of cadmium occurs readily in such boiling acidulated solutions it happens that the iodo-starch test can be employed in this way for the detection of nitrates without difficulty and with a high degree of certainty. The only special precautions to be taken are to test the boiled liquid with litmus paper in order to be sure of its acidity, and to guard against the loss of any nitrous acid by volatilization. This can readily be done by attaching to the small flask in which the nitrate is reduced a small inverted Liebig's condenser, through the sleeve of which a stream of cold water is made to flow. The following experiments will illustrate the delicacy of this new method of testing:

A. 0·0005 grm. N_2O_5, in the form of nitrate of potash, was boiled for five minutes upon metallic cadmium in 50 c.c. of pure water to which two drops of the dilute sulphuric acid, of p. 182, had been added. On testing with iodo-zinc-starch plus acid a strong reaction was obtained, almost immediately.

B. 0·0002 grm. N_2O_5 similarly treated gave a reaction in about five minutes.

C. 0·0001 grm. N_2O_5 gave a reaction in rather less than fifteen minutes.

D. 50 c.c. of pure water acidulated with two drops of the dilute sulphuric acid, and boiled upon cadmium, without any addition of a nitrate, gave no reaction with iodo-zinc-starch plus acid, not even on standing over night.

Repetitions of these trials gave results that were identical with the foregoing.

E. 0·00005 grm. N_2O_5 in 50 c.c. of pure water was tested, as above, in comparison with pure water devoid of nitrate. At the end of half an hour the solution that had contained the nitrate gave a rather strong coloration with the iodo-starch, while the pure water remained perfectly colorless.

F. 0·00001 grm. N_2O_5 in 50 c.c. water was tested as above. But no reaction was obtained with the iodo-starch, not even after the lapse of 36 hours.

G. In order to determine whether metallic cadmium in acidulated water actually destroys peroxide of hydrogen at the temperature of boiling, 100 c c. of pure water were boiled upon cadmium and left to stand in contact with the metal over night; the water thus charged with peroxide was divided into two equal portions, one of which was tested directly with iodo-starch plus acid, while the other was acidulated with two drops of dilute sulphuric acid, again boiled upon cadmium and then tested. A strong reaction was obtained in the portion tested directly, but no reaction was obtained from the acidulated portion until after the lapse of two hours, and then the coloration was but slight. In repeating this experiment, 100 c. c. of pure

water were boiled upon cadmium for five minutes; 50 c. c. of the water were then poured off to be tested, while two drops of dilute sulphuric acid were added to the flask, and the acidulated liquid was again boiled for five minutes with the cadmium. On decanting and testing the acidulated liquid with iodo-starch, it gave no coloration, not even after the mixture had stood over night, while on testing the portion that had been boiled without acid it gave a strong coloration in due course.

II. To see if hydrogen alone would so quickly destroy the peroxide, a stream of hydrogen gas was made to flow during five minutes through a solution of peroxide of hydrogen, prepared as above, that was kept at the temperature of boiling. But the liquid thus treated gave almost as strong a reaction with iodo-starch after the passage of the hydrogen as it had done before.

On trying whether some one of the more common metals might not perhaps be used in testing for nitrates by the new method, it appeared that neither of them is on the whole so well fitted for the purpose as cadmium. Thus on repeating the foregoing experiments, with zinc, amalgamated zinc, aluminum, and iron, it appeared that while no peroxide of hydrogen was formed on boiling acidulated water upon these metals, neither of them was so well fitted as cadmium to reduce nitrates to nitrites in acidulated solutions. From zinc and from amalgamated zinc, distinct reactions were obtained with solutions containing 0·0005 grm. N_2O_5 in 50 c.c. water, when the iodo-starch mixture was left to stand over night, though no coloration appeared until after the lapse of more than two hours; slight reactions were obtained also, after long standing, from solutions that contained 0·0001 grm. N_2O_5; but no reaction was obtained in a solution that contained 0·00005 grm. N_2O_5. From aluminum a slight coloration of the iodo-starch was obtained, after two hours standing, with a solution that contained 0·01 grm. N_2O_5 in 100 c.c. water, and a stronger reaction was got from a solution that contained more of the nitrate. From iron no reaction was obtained, in the course of two hours, with a solution containing 0·01 grm. N_2O_5 in 100 c.c. water, though with a considerably stronger solution a reaction was obtained. A solution containing 0·01 grm. N_2O_5 in 100 c.c. water boiled upon a mixture of iron and platinum gave a reaction almost immediately, but one containing 0·001 grm. N_2O_5 gave no reaction after having been boiled upon the mixed iron and platinum. No reaction was obtained with a solution containing 0·01 grm. N_2O_5 in 100 c.c. water after adding to it a small quantity of acidulated sulphate of silver and boiling the mixture upon iron.

Both lead and magnesium easily reduce nitrates to nitrites in

acidulated solutions, magnesium perhaps even more readily than cadmium, but neither of them would seem to be so good as cadmium for use in testing for nitrates since they form peroxide of hydrogen when boiled in water that is no more strongly acidulated than that just described. The trouble with both metals, but particularly with magnesium, seems to be that they combine with and consume the acid too rapidly so that the solution becomes neutral or well nigh neutral, and fit for the production of peroxide of hydrogen, before the boiling process is finished.

In experiments with lead it was found that a solution containing 0·0001 grm. N_2O_5 in 50 c.c. gave a decided reaction with iodo-starch in less than half an hour, and that a solution containing 0·00005 grm. N_2O_5 gave a distinct reaction in half an hour, though it was not quite as strong as the reaction obtained with cadmium under similar circumstances. 50 c.c. pure water plus two drops dilute sulphuric acid, boiled five minutes upon lead without the addition of any nitrate gave a slight reaction with iodo-starch and acid on standing over night; but on repeating the experiment with four drops of acid no reaction was obtained.

In experiments with magnesium it was found that nitrate solutions containing respectively 0·0001 and 0·00005 grm. N_2O_5 in 50 c.c. water gave reactions with acidulated iodo-starch within fifteen minutes; and that a solution containing 0·00001 grm. N_2O_5 plus four drops of acid gave a distinct reaction on standing over night. But 50 c.c. pure water plus two drops dilute sulphuric acid boiled five minutes upon magnesium without addition of any nitrate gave a slight reaction in the course of two hours, and on repeating the experiment, with four drops of acid a slight reaction was obtained on leaving the mixture to stand over night, though none was visible at the end of two hours. With silver, an acidulated solution containing 0·025 grm. N_2O_5 in 50 c.c. water gave a very slight reaction with iodo-starch in the course of two hours, while a weaker neutral solution, containing 0·01 grm. N_2O_5 in 100 c.c. water, that was boiled upon silver gave no reaction.

It is to be observed that in the foregoing set of experiments the solutions were acidulated in every instance before the boiling, and that an inverted condenser was always attached to the flask in order to prevent the escape of any nitrous acid.

Solutions containing 0·005 grm. N_2O_5 in 50 c.c. acidulated water, left in contact for eight hours or more in the cold with metallic aluminum, iron or zinc, and then tested with iodo-starch gave no reaction in the cases of iron and zinc, and only a slight coloration in the case of aluminum.

No reaction for peroxide of hydrogen was obtained in acid-

ulated water that had been boiled five minutes upon a mixture of pieces of tin and platinum, nor was any reaction obtained from an acidulated solution of nitrate of potash that had been similarly boiled.

Numerous trials were made to discover, if possible, some reducing agent which, though proper to change nitrates to nitrites in neutral solutions, should not form peroxide of hydrogen in such solutions; but all these efforts were unsuccessful. In point of fact there are comparatively few chemicals capable of reducing nitrates to nitrites in presence of much water; while most, if not all. of these substances readily form peroxide of hydrogen when left in contact with water and air. Among metals,* I have found only iron and lead that seem to be at all fit to be used as substitutes for cadmium or zinc, in testing for nitrates by the old method. Both these metals readily reduce nitrates to nitrites in dilute neutral solutions at the boiling temperature; but they, as well as magnesium, aluminum, and copper,† cause the formation of peroxide of hydrogen also, when boiled in pure water. Aluminum, though it reduces nitrates to nitrites in neutral solutions, seems to be inferior to zinc for this purpose, and magnesium, though it reduces nitrates very readily in neutral solutions, seems to form peroxide of hydrogen even more easily than cadmium.

The behavior of iron and lead towards nitrates will appear from the following statement: Neutral solutions of nitrate of potash, containing in 100 c. c. of water 0·01 grm. (or more) of N_2O_5, gave a strong reaction with the iodo-starch, after having been boiled five minutes upon iron wire; with 0·001 grm. N_2O_5 the reaction soon appeared, and with 0·0001 grm. N_2O_5 the reaction appeared after some little time. A special experiment was made, as follows, to test the efficiency of iron as compared with that of cadmium or zinc: 50 c. c. of pure water were boiled for five minutes upon iron wire in one flask, while in another flask 50 c. c. of pure water, plus 0·0005 grm. N_2O_5, in the form of nitrate of potash, were boiled upon an equal amount

* I have, as yet, made no experiments with the alkali metals or their amalgams.

† And various other metals, as recorded in Gmelin Kraut's Handbuch, i (2 Abth.), p. 56.

Since the above statement, that iron forms peroxide of hydrogen on being boiled with water in contact with air, may seem to conflict with Schœnbein's observation that the peroxide is not formed when iron is shaken in water and air, it may be well to give the evidence on which it depends. Pure water was boiled with iron wire for five minutes; the cold liquid was mixed with iodo-zinc-starch solution and dilute sulphuric acid, and left to stand over night. A purplish coloration was obtained. On repeating the experiment, a precisely similar reaction was observed. This coloration is rather less, it should be said, than that obtained from the other metals enumerated above; but is, nevertheless, perfectly distinct and characteristic. In still another experiment, where pure water was boiled upon sheet iron, no reaction for peroxide of hydrogen was obtained. The liquid assumed a rusty tint, and no blue coloration could be perceived.

of the iron wire. When cold, the liquids were transferred to porcelain capsules, mixed with iodo-zinc-starch and acid, and left to stand over night. Decided reactions were obtained in both instances, but the liquid to which the nitrate had been added was deeper colored than the other, and the difference in tint between the contents of the two dishes seemed to be rather more marked than was the case in similar experiments where cadmium or zinc had been used instead of iron. It is not unlikely that iron would have been rather better fitted than either of these metals, for use in testing for nitrates according to the old plan.

On repeating this last experiment with metallic lead, instead of iron, decided reactions were obtained with the iodo-starch in both dishes; but the colorations were of about the same depth as those ordinarily obtained with cadmium, and that obtained from the nitrate solution was no stronger than that from the pure water.

Solutions of nitrate of potash (0·01 grm. N_2O_5 to 100 c. c. water), made alkaline with potash or with lime, were reduced, with formation of some nitrite, when boiled for five minutes upon iron, or left to stand over night in contact with the metal in the cold; but the reactions with iodo-starch that were obtained in this way were less strong than those got by operating upon neutral solutions of the nitrate.

The following substances failed to reduce nitrate of potash when boiled for five minutes with neutral solutions of that substance, containing 0·025 grm. N_2O_5 in 100 c. c. water, or, at the least, no reaction could be obtained with the iodo-starch after using them, viz: filter-paper, phosphorus (ordinary and amorphous), arsenic, ferrous sulphate, ferrous sulphide, and sulphite of lead. No reaction was obtained when acidulated solutions of the nitrate, of the above mentioned strength, were boiled with stannous chloride, ferrous sulphate, glucose, or arsenic. No reduction to nitrite was detected when solutions of the nitrate that had been mixed with lime were digested with ordinary or amorphous phosphorus, glucose, or ferrous sulphide, or when a solution that had been mixed with hydrate of potash was boiled upon metallic arsenic.

On the other hand, recently precipitated cupreous oxide, boiled for five minutes with neutral, acid, and alkaline solutions of nitrate of potash (0·01 N_2O_5 in 100 c. c. water), reduced some of the nitrate in each instance, so that reactions were obtained on adding iodo-starch to the several filtrates, but as the reactions were not very strong there seemed to be little encouragement to proceed with the inquiry.

If it were less difficult than it is, to manipulate with thoroughly boiled water so that no atmospheric air should come

into contact with it, it would be possible, by using such water, to avoid the interference of peroxide of hydrogen, in testing for nitrates in neutral solutions by Schœnbein's process; for, out of contact with the air, no peroxide of hydrogen is formed by the action of cadmium or zinc upon water that has been thoroughly boiled, in a glass flask, provided with a long and very narrow outlet. Even when no special pains are taken to preserve such water from contact with the atmosphere after the boiling, it is easy to perceive that peroxide of hydrogen does not readily form in it. So too, though in a lesser degree, with water that has been well nigh completely deprived of air by distillation in the vacuum of an air-pump. But no such inability to yield peroxide of hydrogen was observed in water that had been boiled for a long time in a copper flask, into the neck of which a long and very narrow brass tube had been soldered. The boiled water from the copper flask gave a reaction for the peroxide even when tested directly, without having been put in contact with any other metal.

I am much indebted to my assistant, Mr. D. S. Lewis, for his coöperation in this investigation.

Bussey Institution, Jamaica Plain, Mass., June, 1876.

ART. XXIII.—*Note on the double decomposition of Potassic Bromide and Sodic Chloride;* by J. H. BILL, Surgeon U. S. Army.

IN the practice of analytical chemistry it is the custom in arranging and recording the results to associate the "strongest acid" with the "strongest base." Thus, if barium, potassium, sulphuric and nitric anhydrides are found in a compound, in the statement of the analysis we associate together the barium and sulphuric anhydride and the potassium and nitric anhydride.

In this record nothing is assumed, for the basic sulphate separates as an insoluble powder, the potassic nitrate remaining in solution a soluble crystalloid.

Again, if potassium, sodium, chlorine and bromine, are found in a mixture we record the results as so much potassic chloride and sodic bromide, or if we mix solutions of potassic bromide and sodic chloride we hold that potassic chloride and sodic bromide exist in the mixture in consequence of a double decomposition. On what do we rest such an assumption? Is it on anything more than analogy? The haloid salts of potassium and of sodium have nearly the same solubility, and crystalline forms. We get no precipitate on mixing their solutions, nor characteristic crystals on evaporating these, nor change of

color in the solutions themselves, nor other evidence that the chemical relations of the several bodies have been altered. In short our belief in this alteration is purely hypothetical.

Several years ago while conducting a physiological research on the action of the bromides I observed certain facts which I here offer as a demonstration of the proposition that potassic bromide and sodic chloride, when brought together in solution, undergo double decomposition.

If five or six grams of potassic bromide are administered to a healthy man, his urine of the succeeding twenty-four hours will show the following changes: Nearly all the potassium ingested as potassic bromide will be found in the urine in addition to that naturally present, united with chlorine augmented according to the amount of bromide taken; the sodium scarcely altered in quantity; the sulphates and phosphates unchanged; only a very little bromine will be found. Bromides, however, may be detected for two weeks after the last dose taken, whilst excess of potassium will be found only after the first day.

I can account for these facts only on the supposition that the potassic bromide ingested was decomposed by the sodic chloride of the blood, potassic chloride—excreted by the urine—and sodic bromide—retained in the blood as a substitute for sodic chloride—resulting.

Further, this decomposition was the result of simple chemical affinity. We know of no instance where a "vital force" changes in the body the usual action of chemical force and we have no right to assume it here. We hold the reaction therefore to be a universal one. I submit the average result of three analyses when no bromide was taken, and the average results of six analyses of urine when the body was under the influence of from five to ten grams of potassic bromide. The results show the amounts of the whole twenty-four hours, all the urine for that period being collected. The method was to incinerate a portion of the urine and from the ash to separate the alkaline earths, sulphates and phosphates. The sodium and potassium were then estimated in the form of chlorides by the indirect method. The chlorine and bromine were also estimated indirectly.

	Potassium. grms.	Sodium. grms.	Chlorine. grms.	Bromide. grms.
No bromide taken	4·21	7·67	9·56	----
Seven grains (average) of bromide taken	6·52	7·82	11·45	0·04

I have waited for a chance to extend these experiments to the reaction of the iodides and chlorides, but seeing no probability that an immediate opportunity of doing so will present itself I publish this note for what it is worth.

New York, June 15, 1876.

ART. XXIV.—*Note on Erosion;* by JAMES D. DANA.

IN Professor Gilbert's very valuable paper on "The Colorado Plateau Province,"* the author speaks of the process of erosion† as including the three general divisions, "(1) *weathering*, (2) *transportation*, and (3) *corrasion*;" and states that "corrasion is performed by solution, and by mechanical wear;" that the mechanical wear is due to the blows which the moving fragments [of the detritus] deal upon the stream bed, and among themselves; and that "the element of velocity is of double importance, since it determines, not only the speed, but, to a great extent, the size of the pestles which grind the rocks." He further observes, in his excellent explanatory analysis of the mechanical action of flowing water, that the energy of a stream is used up in transportation, corrasion, and friction, either one or all; and that sometimes partly also, but not usually so, in producing an increase in the velocity of flow; that the energy "in a clear stream is entirely consumed in friction on its bottom," and in one that is loaded to its full capacity with detritus, in transportation. From these principles, he concludes that "if a stream has no load of detritus it corrades only by solution," that is, by softening and dissolving away the rocks.

The eroding action directly connected with friction is not dwelt upon by Professor Gilbert, nor distinctly included in the "general divisions" of erosion which he enumerates, although he is unquestionably familiar with the facts; and a few words on the subject are therefore here added, since an appreciation of the work which may thus be done appears to be essential to a full understanding of the method of cañon-making.

The impinging of the flowing waters against the bottom and sides of a stream generally causes, besides a diminution of velocity owing to friction, an overcoming of adhesion, and of other sources of resistance to displacement, in the material acted upon. The operation is exhibited, on a small scale, at the placers of California and the Rocky Mountains, where a stream of water—strictly a water-fall—strikes, in a jet, the rather firmly consolidated gravel bank, and, in an incredibly short time, levels the thick deposits over a large area. The water that impinges has "no load of detritus," and yet it erodes with tremendous efficiency. The flooded rivers that tear houses from their foundations, and break off or uproot trees, afford other examples; for the work is, first, rending, and then, transportation. The sudden rise of several feet or yards in a mountain stream, or along a western cañon, sometimes occurring as

* This volume, pages 16, 85. † Ibid., p. 89.

a consequence of a severe and short storm, often affords, as is well known, vast effects of this kind.

Flowing water, causes easily, through this method of erosion, a rapid destruction of those deposits that are imperfectly cemented; but not these alone. It may cause a rapid degradation also of hard rocks. For granite, quartzyte, sandstone, limestone, and other rocks equally firm, are generally jointed throughout, that is, intersected everywhere by a system of fractures; and many kinds also break easily into slates, flags, or chips, even without a previous weakening by weathering. Consequently, when the waters, swollen to flood height and quickened immensely in velocity, plunge along a gorge, they readily tear, shove, or wrench out of place blocks or slabs exposed in the walls to their violence. As the waters hurry on, they dash in many places, with the full force of the stream, against projecting ledges, and drive into all crevices or openings, causing a vast amount of degradation; and much additional by undermining and toppling down the piles of strata above.

Such waters in the rocky regions of the west, where the bed and gorge are rock-made, transport, in their greatest floods but a small part of the detritus which at so rapid a rate of flow they could carry, and hence, comparatively little of the energy is used up in transportation. Moreover, the descent in the cañoned streams of the Rocky Mountain slopes is often—much oftener, probably, than Professor Gilbert seems to allow—sufficient to produce an increasing velocity as a direct consequence of the fall, and hence an accumulation, thereby, of working force or energy; and all this would augment greatly the results. The clearer the waters, the greater will be the velocity, and, hence, the vaster the amount of degradation by this means—though detritus would increase the effects if the velocity remained the same.

It has been well said that glaciers depend largely for their work in the way of erosion on the jointed condition of the rocks over which they pass, these making it easy for the moving ice to force out of place great masses for transportation, and so make rapid progress in degradation; and that the abrasion by means of stones in the bottom of the ice is comparatively of trifling importance. I am strongly inclined to believe that the same general fact is true as regards erosion by rapid rivers over a rocky region; and hence that the results of *friction*, or of the *blows of the impinging torrent*, are the chief means of degradation in most cases of cañon-making; that *abrasion*, or the wear of the sides and bottom by transported stones and earth (included under corrasion by Professor Gilbert), is of next importance; while the mutual wear of the transported particles or fragments, or *corrasion*, aids in clearing the gorge of the dislodged material.

ART. XXV.—*Classified List of Rocks observed in the Huronian Series, south of Lake Superior, with remarks on their abundance, transitions, and geographical distribution; also a tabular presentation of the Sequence of the beds, with an Hypothesis of Equivalency;* by T. B. BROOKS.

DURING the last ten years I have explored more or less thoroughly the east and north portions—about one-third—of the large Archæan area lying southwest of Lake Superior, embracing the iron and copper regions of northern Michigan and Wisconsin.* Besides observations in the field, I have collected and catalogued over 3,000 rock specimens, mostly Huronian, embracing, it is believed, all the kinds and most of the varieties to be observed in that portion of the region which came under my observation. The most interesting of these specimens having now been more or less thoroughly studied by competent lithologists, I feel warranted in preparing the following list of names with classification. They are based largely on a microscopic study of over 200 thin sections of typical rocks, made by Dr. A. Wichmann† of Leipsic under the supervision of Prof. Zirkel, an equal amount of similar work by Mr. Chas. E. Wright,‡ together with a considerable number of similar examinations made by Mr. Frank Rutley of London. Dr. T. S. Hunt has compared a large number with the Huronian rocks of Canada; Dr. A. Törnebohm of Stockholm has made similar comparisons with rocks of Scandinavia, and Herr B. Wapler of Freiberg, with the rocks of Saxony. Prof. Geo. J. Brush has made several analyses and determinations of essential mineral constituents. Prof. R. Pumpelly placed at my disposal his numerous field-notes, made in the Archæan area. Mr. A. A. Julien has minutely described the physical characters of these rocks in Appendix A, vol. ii, of the Michigan Geological Reports, 1873.

From this material the nomenclature given below has been chiefly drawn. As many of the rocks are fine-grained, often aphanitic mixtures of obscure amphibolic and feldspathic minerals, the different kinds and varieties graduating into each other, it is to be expected that similar specimens would often receive different names. This has been particularly the case with the hornblendic rocks, diorytes, diabases, and certain related chloritic schists, also to a less extent with hydro-magne-

* For geographical distribution and structural relations of the copper-bearing rocks, see Brooks and Pumpelly, Am. Jour. Sci., vol. iii, June, 1872; also for Archæan of Michigan, their Map No. 1, Atlas of Michigan Geological Survey, 1873. But little of Northern Wisconsin is mapped in detail.

† Dr. Wichmann is preparing a paper embodying the results of his labors.

‡ Mr. Wright's work was done for the Wisconsin Geological Survey, but the results are not yet published.

sian, argillaceous, and micaceous rocks. An effort has been made to reconcile these different views through the results of the microscopic investigations of the gentlemen above named, as well as by observations in the field, where a fine-grained or altered rock can often be traced through its various transitions to a coarser and typical variety.

The age and distribution of the different members of the Huronian series given in the annexed table are chiefly based on my own observations; use, however, has been made of the notes of Prof. Pumpelly and Mr. Wright, and the publications of Dr. Credner, whose descriptions of the transitions of the various rocks are excellent. The hypothetical scheme of equivalency presented in the table is my own.* That subject was also discussed in a paper entitled, "On the youngest Huronian Rocks south of Lake Superior, and the age of the Copper-bearing Series."†

The thickness of the Huronian series, which are everywhere sharply folded, thus presenting their upturned edges which are often abruptly curved, striking at every point of the compass, —can only be determined with exactness by a protracted study of many sections. Exclusive of the youngest observed member (the granite bed XX, only recently made out), the thickness seems least in the Marquette and western districts, where it is believed not to exceed 6,000 feet, and greatest in the Menominee Region, where it may exceed 12,000 feet. I do not know how Dr. Credner obtained his estimate of 18,000 ft.‡ as the thickness of the sixteen oldest beds of my scheme (the only ones he examined) in the Menominee Region. In one instance, however, owing to his having mistaken cleavage for bedding planes (bed IX), he overlooked at least one synclinal and one anticlinal fold, thus counting the same bed at least three times.

The lithological classification adopted is that given in the second edition of Dana's Manual of Geology, 1875, as best embracing the facts. No other classification of rocks that has come under my notice admits the so-called greenstones among metamorphic rocks, where, following the lead of the Canadian geologists, I would place the diorytes, diabases, and related schists, so abundant in the Huronian area south of Lake Superior, especially in the eastern portion, which is nearest the Huronian of Canada.

* Dr. H. Credner makes my oldest fourteen beds of the Marquette series the equivalents of the quartzyte bed II of the Menominee series. See Zeitschrift der deutschen geologischen Gesellschaft, xxi Band, 1869. His having failed to recognize the upper Huronian, detracts considerably from the weight of this hypothesis.

† Published in the proceding volume of this Journal, page 206.

‡ See his article referred to in the above note.

EXPLANATIONS.

1st. The numbers following many names refer to typical specimens of that rock contained in my Michigan State Collection (see catalogue * in Geological Survey of Michigan, 1873, vol. ii, p. 201), partial duplicate suites of which were furnished the University of Michigan, Boston Institute of Technology, Harvard University, Sheffield Scientific School, the Schools of Mines in New York and Philadelphia, Smithsonian Institution, as well as several other American and foreign institutions. See list in the report named above. The same numbers repeated in the table indicate their stratigraphical position, and the region from which obtained.†

2d. Those rocks marked L have also been observed in the Laurentian system, which has however been but little explored. No Huronian rocks are believed to be identical with those of the copper-bearing series, although some of the greenstones have considerable resemblance.

3d. The Marquette region embraces the important iron-mining district southeast of Keeweenaw Bay; of which Marquette in Michigan is the chief port. About fifty or sixty miles south is the undeveloped Menominee iron region extending into Wisconsin. One hundred and twenty-five miles west of Marquette, on Black River, Mich., and thirty miles farther west, where Bad River crosses the Penokie Iron Range, Wis., the Huronian series is well exposed. See table.

4th. The Roman numerals of the table express the approximate relative age of the twenty beds into which it has been found convenient to divide the Huronian of the Marquette and Menominee regions, numbered from the oldest upward. The equivalency has been extended with less certainty to the Black River and Bad River series, and with still less to the Huronian of Canada. See table.

5th. The names of rocks which have not been observed in the Huronian are usually printed in italics.

6th. The varieties of each kind of rock are arranged in the order of relative abundance, so far as known.

1. FRAGMENTAL ROCKS, EXCLUSIVE OF LIMESTONES.

True quartz-conglomerates are not abundant, but occur in the Middle Huronian, both in the Marquette and Menominee Regions; and in the latter, at the base of the series, is a protogine conglomerate holding pebbles of granite, gneiss, and quartz.

* A supplementary revised and extended descriptive catalogue of this typical suite, now much extended, is in course of preparation.

† The specimen numbers in italics were selected by Dr. Wichmann as possessing the greatest lithological interest. Duplicates have been given to R. Fuess, Berlin, from which I understand he will furnish mounted thin sections.

The Sequence of Huronian Strata at several points near Lake Superior, with Hypothesis of Equival

By T. B. BROOKS.

NORTH OF LAKE HURON, CANADA.	MARQUETTE IRON REGION, MICHIGAN.	MENOMINEE IRON REGION, MICH. AND WISC.	BLACK RIVER SERIES, Between Lake Gogebic and Montreal River, MICHIGAN.	BAD RIVER AND PENOK WISCONSIN.
Geology of Canada, 1863.	**T. B. Brooks.**	**Pumpelly, Brooks, Credner, Wright.**	**Pumpelly and Brooks.**	**T. B. Brooks.**
NOTE.—Important beds of iron-ore, probably of Huronian age, occur near the eastern shore of Lake Superior in Canada, but their stratigraphical position is not known to me.	**LOWER SILURIAN.** COPPER SERIES (WANTING).	**LOWER SILURIAN.** COPPER SERIES (WANTING).	**LOWER SILURIAN.** NON-CONFORMABLE WITH COPPER SERIES,	**LOWER SILURIA** NON-CONFORMABLE WITH COPP
	XIX. Grayish-black *mica schist*, often *staurolitic* and holding *andalusite* and garnets; rarely *chloritic schist*. Quartz in bunches and veins, and hornblende seams, rare. No. 61.	XIX. Brownish-black *mica schist*, sometimes *staurolitic*, and *hornblende* schist; rarely gneiss, chloritic schist. Granite dykes. Nos. 90, 108, 128, 125, 103, 134.	Here believed to overlie non-conformably and conceal the Upper Huronian.	Believed to be non-conforma the following.
l. White *quartz*, *chert* and *limestone.*	Quartzyte? Probably soft slate.	XVIII. *Quartzyte*, with *chloritic*, *micaceous* and *argillaceous* schists and slates, rarely carbonaceous. Nos. 138, 140, 133.	Compact *greenstone* with green cherty? layers. Bright red specks of jasper and crystals of pyrite.	Red, gray, coarse and fine grain rock, rarely schistose.
k. Yellow *chert* and *limestone.*	XVII. *Anthophyllitic? schist*, usually magnetic, and containing manganese. 58, 59.	XVII. Chiefly *hornblende schist* and related *greenstones* and *chloritic schist;* perhaps chloritic and micaceous quartzose schist in small quantities. 126, 127, 105.	*Greenstone;* holds grains of glassy quartz and appears chloritic.	*Greenstone* or hornblende r ently chloritic, (somewhat soft,
i. White *quartzyte.*	XVI. Banded ochrey porous *quartz* schist. 57.	XVI. Chiefly *clay slate* without oblique cleavage, or chlorito-argillaceous slate, often *ferruginous* or *carbonaceous;* also hydrous magnesian schists, mostly *chloritic;* micaceous *quartz schists; hematite* schist; rarely hornblende rocks and greenstones. 114, 115, 146, 135.	*Hematitic* and *magnetic quartzose flag.* (Like Marquette flag ores.)	[Covered about ½ mile
Greenstone.	XV. Blackish *argillaceous slate*, with imperfect cleavage, rarely micaceous, and sometimes holding garnets. 56.	XV. *Gabbro* (or *diabase*) in a heavy bed with other greenstones and related *chloritic* schists, also ferruginous (anthophyllitic?) schist and actinolyte schist. 69, 119, 129.	Gray, green, and brown, *banded, ferruginous, siliceous slate*, with strong rhombohedral cleavage.	Clay slate?
Yellowish *chert* and *limestone.*	XIV. Gray arenaceous *quartzyte*, often semi-schistose and sometimes micaceous; quartz conglomerate. 50, 51, 145.	XIV. Unctuous-feeling hydrous *magnesian schist; sericite; quartzyte*, holding micaceous iron and in places *conglomeritic;* and chloritic *greenstones.*	Grayish and greenish *banded schist*, weathering brown, apparently *chloritic*, with *jaspery* layers. Contains pyrites. In places apparently felsitic and again aphanitic.	*Magnetic amphibolic quartzos* quartzose magnetic ore. 148. forming crest of ridge.
i. White *quartzyte.*	XIII. Pure specular *hematite* and *magnetite* ores; ferruginous banded *jaspery* schist, with interstratified beds of *chloritic* and hydromicaceous schists. "Trap dykes" at Washington Mine. 36 to 49, 52 to 55, 89. 79, 94.	XIII. *Chloro-argillaceous slate, chloritic schist. dioryte, carbonaceous clay slate*, and ferruginous anthophyllitic schist. 130.	[Covered.]	Black *clay slate* without obl age.
h. Red *jasper conglomerate.*	XII. Red arenaceous *quartz schist*, banded with *micaceous-iron; quartzose limonitic* ores. 32, 33, 34, 35.	*Hornblende rock* and *chlorite-mica schist.* 106.	*Ferruginous, banded* (purple and green) *cherty schist* (magnetic).	Gray *quartz* schist, banded sional lamina of *magnetic ore.*
g. Red *quartzyte?*	XI. *Dioryte, hornblende schist, chloritic schist*, chloritic-looking *mica schist;* rarely hornblende gneiss. 118, 29, 30, 107.	*Micaceous clay slate* (phyllite) with seams of quartz; carbonaceous clay slate. 111.	Banded ferruginous *jasper schist.*	Grayish and reddish *quartzos*
f. Slate *conglomerate* with beds of *greenstone.*	X. Siliceous *hematitic* and *limonitic* schistose ores, often *manganiferous; siliceous* schists; garnetiferous anthophyllitic (eklogyte) schists; obscure compact chloritic? magnetic schists, with conchoidal fracture. 24, 25, 26, 23, 27, 131, 28.	Whitish *dolomitic marble*, with crystals of tremolite and wollastonite. 142.	Ferruginous *siliceous flags* (not magnetic).	*Greenstone* (thin bed).
			Arenaceous *quartzose schist.*	Soft, light gray-green *slate*
			Reddish *quartzyte.*	chloro-argillaceous.
e. Limestone, some beds *dolomitic* and ribbed.	IX. *Hornblendic rock* and related *dioryte*, and *diabase*, often micaceous. 22, 88, 31.	Chiefly obliquely cleavable *clay-slate;* with dark-gray, arenaceous, deep weathering quartzyte; also mica schist. 113, 139.	Hydrous magnesian or *argillaceous schist.*	
	VIII. Ferruginous *quartzose flags; clay slate; quartzyte*, rarely chloritic and anthophyllitic? schist. 19, 20, 21.		*Greenstone.*	Gray *quartzose schist* faintly
d. Slate *conglomerate*, with heavy interstratified beds of *greenstone.*	VII. *Hornblendic rocks*, with related greenstones? 18.	*Hornblende schist.* Hydrous *magnesian schist* and probably ferruginous clay slate; perhaps sericite. 112.	Banded *cherty schist* and schistose cherty *breccia*, more or less ferruginous. 84, 85. Compact hard *greenstone.*	
	VI. *Ferruginous quartzose* schist; *clay* and *chloritic* slates? 15, 16, 17.	VI. Soft specular *hematite schist* and *siliceous flag ore; ferruginous clay slates;* hydrous *magnesian schist;* rarely granite dykes. 136, 67, 68.	Very soft, apparently chloritic *greenstone.*	Gray to white, massive *quar* bed.
c. White *quartzyte*, sometimes *conglomeritic.*	V. *Quartzyte* graduating into *protogine*, with interstratified beds of *dolomitic marble; novaculyte;* rarely chloritic and micaceous schist, and dykes of chloritic schist. 8, 9, 11, 10. 12, 13.	V. Grayish to white crystalline *dolomitic marble*, with quartz or cherty laminæ, presenting often a ribbed surface; with rare beds of gray quartzyte and hydrous magnesian schist. 66, 143.	Gray, banded, *slaty schist.*	
			[Covered 100 steps.]	Calcareous rock?
Greenstone.	*Syenyte* (quartzless), *dioryte, diabase, hornblende schist*, and obscure chloritic slates, conglomeritic *quartzyte* and various *quartzose iron ores.* Well-characterized *talc schist* is found in this horizon only at Marquette. 77, 116, 75, 72, 120, 121, 71, 76. 2, 5, 6, 73, 74.	IV. Arenaceous *magnetic mica schist.* 109.	*Greenstone.* Banded *ferruginous, siliceous schist*, strongly magnetic. *Greenstone.*	
b. Chloritic and *epidotic slates.*		III. Soft schist? Not made out.	Banded *ferruginous slate.*	Amphibole schist and per blendic gneiss in heavy beds.
a. Quartzyte, strong and solid, and resisting well the influence of the weather. Slate *conglomerate.*		II. White to gray, compact, massive to semi-schistose, arenaceous *quartzyte*, in places micaceous and actinolitic, holding considerable specular iron at one point. Sometimes ripple-marked. 137.	Massive *greenstone* apparently chloritic.	
		I. *Chloritic* (protogine) *gneiss;* hydrous magnesian schist; schistose conglomerate; quartzyte; and perhaps dioryte. 65, 102.	Banded ferruginous *jasper schist.*	[Covered.]
LAURENTIAN.	NON-CONFORMABLE WITH LAURENTIAN.	NON-CONFORMABLE WITH LAURENTIAN.	NON-CONFORMABLE WITH LAURENTIAN.	BELIEVED TO BE NON-CONFORM LAURENTIAN.

NOTE.—The equivalency of beds V., VI. and XIX. of the Marquette and Menominee series is regarded as established, and the intervening beds are believed to be nearly as arranged. The equivalency the Western series is only provisional; and even this much is not asserted in the case of the Canadian. The figures refer to specimens of typical rocks from certain beds, named in the accompanying See accompanying explanations.

r Lake Superior, with Hypothesis of Equivalency.

OOKS.

REGION,
ISC.
dner, Wright.
RIAN.
ANTING).
See Nos. 101,
ca schist, some-
blende schist;
hist. Granite
125, 103, 134.
chloritic, mica-
sts and slates,
138, 140, 133.
schist and re-
tic schist; per-
eous quartzose
126, 127, 105.
vithout oblique
llaceous slate,
ceous; also hy-
ostly chloritic;
ematite schist;
d greenstones.
in a heavy bed
related chloritic
nthophyllitic ?)
69, 119, 129.
ydrous magne-
yte, holding mi-
conglomeritic;
slate, chloritic
clay slate, and
chist. 130.
rite-mica schist.
ite) with seams
y slate. 111.
, with crystals
e. 142.
ble clay-slate;
deep weather-
ist. 113, 139.
t and probably
erhaps sericite.
atite schist and
us clay slates;
rarely granite
talline dolomitic
ty laminæ, pre-
ace; with rare
hydrous mag-
ic mica schist.
nde out.
act, massive to
quartzyte, in
olitic, holding
at one point.
137.
neiss; hydrous
conglomerate;
yte. 65, 102.
WITH
N.

BLACK RIVER SERIES,
Between Lake Gogebic and Montreal River,
MICHIGAN.

Pumpelly and Brooks.

LOWER SILURIAN.

NON-CONFORMABLE WITH COPPER SERIES,

Here believed to overlie non-conformably and conceal the Upper Huronian.

Compact *greenstone* with green cherty? layers. Bright red specks of jasper and crystals of pyrite.

Greenstone; holds grains of glassy quartz and appears chloritic.

Hematitic and *magnetic quartzose flag.* (Like Marquette flag ores.)

Gray, green, and brown, *banded, ferruginous, siliceous slate,* with strong rhombohedral cleavage.

Grayish and greenish *banded schist,* weathering brown, apparently *chloritic,* with *jaspery* layers. Contains pyrites. In places apparently felsitic and again aphanitic.

[Covered.]

Ferruginous, banded (purple and green) *cherty schist* (magnetic).

Banded ferruginous *jasper schist.*

Ferruginous *siliceous flags* (not magnetic).

Arenaceous *quartzose schist.*

Reddish *quartzyte.*

Hydrous magnesian or *argillaceous schist.*

Greenstone.

Banded *cherty schist* and schistose cherty *breccia,* more or less ferruginous. 84, 85.

Compact hard *greenstone.*

Very soft, apparently chloritic *greenstone.*

Gray, banded, *slaty schist.*

[Covered 100 steps.]

Greenstone.

Banded *ferruginous, siliceous schist,* strongly magnetic.

Greenstone.

Banded *ferruginous slate.*

Massive *greenstone* apparently chloritic.

Banded ferruginous *jasper schist.*

NON-CONFORMABLE WITH LAURENTIAN.

BAD RIVER AND PENOKIE GAP,
WISCONSIN.

T. B. Brooks.

LOWER SILURIAN.

NON-CONFORMABLE WITH COPPER SERIES,

Believed to be non-conformable with the following.

Red, gray, coarse and fine grained, *granitic* rock, rarely schistose.

Greenstone or hornblende rock, apparently chloritic, (somewhat soft, but tough).

[Covered about ½ mile.]

Clay slate?

Magnetic amphibolic quartzose flags, and quartzose magnetic ore. 148. Heavy bed forming crest of ridge.

Black *clay slate* without oblique cleavage.

Gray *quartz* schist, banded with occasional laminæ of *magnetic ore.*

Grayish and reddish *quartzose schist.*

Greenstone (thin bed).

Soft, light gray-green *slate,* probably chloro-argillaceous.

Gray *quartzose schist* faintly banded.

Gray to white, massive *quartzyte.* Thin bed.

Calcareous rock?

Amphibole schist and perhaps hornblendic gneiss in heavy beds.

[Covered.]

BELIEVED TO BE NON-CONFORMABLE WITH LAURENTIAN.

shed, and the intervening beds are believed to be nearly as arranged. The equivalency indicated for
res refer to specimens of typical rocks from certain beds, named in the accompanying Classified List.

Laminæ of quartz-sandstone occur in magnetite at one locality, and arenaceous quartzytes approaching sandstones at several points. Shaly argillaceous rocks without oblique cleavage, in places highly carbonaceous, are somewhat common; and earthy limonites, having the character of residual deposits, occur in the Marquette Region. These rocks would strictly belong in this class, but as their quantity is comparatively small, and as they are interstratified with and graduate into metamorphic rocks, of which they often appear to be altered forms, they are classed below, where they may stand for the least metamorphosed varieties of the series.

2. Metamorphic Rocks, not Calcareous.

1. *The Mica-bearing Series.*

(1.) *Granite.* (L.) Confined to the youngest bed; also occurs rarely in veins in Lower and Upper Huronian. Common (gray)—*101*. Gneissic. Semi-porphyritic.

(2.) *Pegmatyte.*

(3.) *Granulyte?*—146. Very rare, may exist in the Menominee Region.

(4.) *Gneiss.* (L.) Not abundant, mostly associated with granite. Common (gray)—*102*. Granitic—7. Semi-porphyritic. Compact, related to greenstones—*103*.

(5.) *Mica Schist.* (L.) Abundant, especially in the younger rocks of the Marquette Region. Common, blackish and brownish. Often staurolitic and holding andalusite (Brush)—61. Garnetiferous—108, 56? Quartzose. Hornblendic—*106* (massive, semi-porphyritic?—rare). Green, chloritic—107 (associated with greenstone). Gray, arenaceous, semi-schistose, with mica-scales—*104*. Gneissic—90. Magnetic (L.)—*109*, (rare). Actinolitic—105. The last three varieties have been observed only in the Menominee Region.

(6.) *Mica Slate.* (L.)—53?

(7.) *Hydro-mica Slate?*—53, 54. Unctuous-feeling, micaceous rocks, interstratified with iron-ores; they have been called talcoid schists. Sericite—*112*.

8. *Clay Slate or Argillyte.* *a.* Without oblique cleavage, usually in independent beds. Chloritic—114? Carbonaceous (including so-called graphitic varieties)—64, 115. Ferruginous, associated with hematites and limonites. Micaceous, (phyllyte) —111, 56? Feldspathic (arenaceous obscure varieties)—*55?* Pyritiferous. *b.* With oblique cleavage, usually associated with quartzytes or marbles—113, 20. Roofing—81. Novaculyte—10, *12*, 13.

2. *Hornblendic Series.*

(1.) *Syenyte* (containing quartz). (L.)

(1*b*.) *Syenytic Gneiss* (Hornblende Gneiss). (L.)—*117*. Not abundant; rare in the Marquette Region, where it only occurs as a transition variety of greenstone.

(2.) *Hyposyenyte* (quartzless syenyte). Observed only in the Lower Huronian near Marquette, associated with greenstone, into which it seems to graduate. Rich in orthoclase—*116*. Hornblendic—77.

(2*b*.) *Zircon-syenyte.*

(3.) *Dioryte*—75, *118*. Grayish-green, fine to coarse grained. Abundant, especially in the eastern part of the Marquette Region, graduating into hornblendic rocks on the one hand, and, through schistose varieties and diabases (?), into chloritic schists on the other. Hornblendic. Chloritic (schistose)—71? Semi-porphyritic.

(3′.) *Gabbro**?—69. Confined to bed XV, in the Menominee Region.

(4.) *Hypersthenyte.*

(5.) *Diabasyte.*† Abundant, especially south of L'Anse. This name is often applied by Dr. Wichmann to obscure, fine-grained greenstones which have usually been called diorytes, dioritic schists and chloritic diorytes Decomposed—99, *120*, 121, 122. Often closely related to one variety of chloritic schist—70. Green, related to dioryte—72, 119, 69. Black, somewhat coarse-grained, highly crystalline, distinct from the other greenstones —*82*. Porphyritic?—83. Micaceous?—31.

(6.) *Hornblende Schist.* (L.) Abundant. Greenish-black, coarse-grained, semi-schistose to massive, graduating into greenstone —18, 22, 30, 88. Eminently schistose, fine-grained, associated with mica schist—128, *125*. Micaceous—29, *127*, 71? Chloritic —76. Calcareous—*124*, rare.

(7.) *Hornblendyte.* (L.?)—*126*. Far less abundant than the schist.

(8.) *Actinolyte—129*. Chiefly confined to the Menominee Region. Not abundant.

Anthophyllite Schist‡ (Brush). Quite abundant in the Marquette and Menominee Regions, and always associated with magnetite. Manganiferous—*58*, 59. Quartzose—130. Garnetiferous (eklogyte)—*27*.§

* Dana does not mention gabbro among the metamorphic rocks. As several lithologists agree on the name, and the bed has all of the structural characteristics of the others of this series, I place it here, although Dr. Wichmann regards the rock as diabase.

† From microscopic researches, Dr. Wichmann and Mr. Törnebohme, with whom Prof. Zirkel agrees, regard these Huronian greenstones, the diorytes and diabases, as mostly diabasytes, and consider them of eruptive origin. Regarding them myself as metamorphic, I should have employed the term *meta-diabase*, as lately suggested by Prof. Dana, had it come to my knowledge in time.—Note in letter dated Edinburgh, June 27.

‡ This rock does not occur as a distinct kind in Dana's classification.

§ Dr. Wichmann's microscopic examinations lead him to regard this rock as made up largely of actinolite.—Letter, dated July 27.

(9.) *Pyroxenyte* (augite rock). (10.) *Lherzolyte.* (11.) *Ossipyte.* (12.) *Unakyte.*

3. ***Felsitic, Epidotic, and Garnet Rocks*** **(L. ?),**

Having the mass, or base, compact (crypto-crystalline).

No typical rocks of this family have been observed. The nearest kind is a gray, magnetic, amphibolic schist, containing garnets, and closely related to the anthophyllite schists, but which Dr. Wichmann designates eklogyte—*27.*

4. ***Chrysolite (or Olivine) Rocks.*** **Not observed.**

5. ***Hydrous Magnesian Series.***

(1.) *Protogine* (L.)—3. Not abundant. Quartzyte graduates into this rock in the Marquette Region. In the lowest Huronian of the Menominee Region, holding pebbles of granite, gneiss and quartz—65.

(2.) *Feldspathic Protogine Gneiss?*—147. Has been called graywacke. Occurs only in the Menominee Region in one bed.

(3.) *Talcose Slate*—74. A typical kind has been observed only at Marquette. Unctuous-feeling micaceous and chloritic rocks, often called talcose, are more abundant.

(4.) *Steatyte or Soapstone.*—Said to exist.

(5.) *Chloritic Slate* (schist). (L.?) Abundant. A hard, very unevenly schistose, gray-green variety, associated with greenstones and hornblendic schists, of which it appears to be an altered or chloritic form, (has received different names)—133, 70? Gray-green, splitting into somewhat uneven thick slates, and related to micaceous and argillaceous rocks—132, *134.* A fissile variety, graduating into clay slate, under which it should perhaps be classed—*55*, 114? Dark-green, pure, massive, containing pseudomorphs after magnetite, garnet, and amphibole, occurs in iron-ore—*89.* Ferruginous. Micaceous, in greenstone. Compact, magnetic, conchoidal fracture—28?

(6.) *Chloritic Argillyte.* A slate termed chloro-argillaceous, is very abundant in the Menominee Region—114. Often carbonaceous.

(7.) *Serpentine—78.* Very rare. Apparently altered greenstone, and having somewhat of an eruptive character.

(8.) *Ophiolyte.* (9.) *Schilleryte.*

6. ***Hydrous Aluminous Rocks.*** **Not observed.**

7. ***Quartzose Rocks.***

(1.) *Quartzyte.* Very abundant, graduating into marble on one hand, and into protogine on the other, containing beds of clay slate with oblique cleavage. White to light-gray, massive, arenaceous, often with glassy grains, occasionally with ripple-marks, and on Black River showing the false stratification

of sandstone—8, 21, *137*. Micaceous quartz schist, often conglomeritic—*140*, 50, 51. Quartz conglomerate (see remarks under "Fragmental Rocks"), associated with and constituting a variety of the above—145. Chloritic arenaceous—138. Blue-gray, arenaceous, weathering to a brown sandstone—*139*. Banded magnetite and arenaceous quartz schist—52. Micaceous and specular iron—32, 33, 49. Limonitic—26. (The three last varieties are also classed under Iron-ore rocks.) Calcareous.

(2.) *Siliceous Schists*, compact, often slaty, generally ferruginous, and graduating into siliceous flaggy iron-ores, are abundant. Poor in iron. Rich in iron (siliceous flag ores)—23, 36, 68. (See Iron-ore rocks.)

(3.) *Chert*. A flinty rock, flaggy to slaty, between siliceous schist and jasper, abundant only in the middle of the Black River series. Sometimes brecciated—85, 84? Lydianstone—very rare.

(4.) *Itacolumyte*.

(5.) *Jasper Rock*. An impure reddish variety, banded with specular ore, is abundant in the Marquette Region—*37*. Better characterized, banded, often ferruginous, jaspers occur with chert in the Black River series. Sometimes brecciated—84, 85?

(6.) *Buhrstone*.

8. *Iron-ore Rocks.*

Magnetites, *Hematites* (usually specular), *Limonites*, and related ferruginous rocks are very abundant in the Middle and Lower Huronian, especially in the eastern portion of this Huronian area, while they are comparatively rare in the same series in Canada. At least seven out of the twenty beds of the Marquette Region are ferruginous, and four have produced first-class ores. The rich specular hematite, which is so far most extensively mined, is mostly confined, however, to bed XIII, in which the richest magnetites also occur. There is less iron in the Menominee Region, and still less and of lower grade, so far as observed, in the Black River and Bad River series.

The magnetites and specular hematites graduate into each other through martite, which is abundant. They are also sometimes interstratified in the same bed, although seldom in juxtaposition. Nearly the same may be said of the hematites and limonites, but not of the latter and magnetites, which are never found together. These facts support the hypothesis that these ores, whatever their origin, were once all magnetites, part of which were afterward oxidized to hematites, and part of these in turn into limonites.

No rocks are embraced below which do not occur in considerable beds. To include all of them I have found it necessary to considerably expand the skeleton given by Professor Dana,

and to add limonites, which are so closely related to the others that it was not attempted to separate them here.

Iron-oxide, except as disseminated grains of magnetite and in a few instances in small unworkable beds, is entirely absent from the Laurentian and Copper-bearing series of the Archæan south of Lake Superior, while in Canada the largest deposits are reported as occurring in the Laurentian. Titaniferous iron-ore, so abundant in the Archæan of Canada and northern New York, has not been observed south of Lake Superior. In several hundred analyses of these ores,* I have only once seen "a trace" of titanium reported. Franklinite has not been observed.

(A.) *Magnetites and Magnetic Quartzose and Amphibolic Rocks.* Most abundant and, except the amphibolic kinds, found only in typical forms in the western part of the Marquette Region.

a. *Rich in iron (iron-ores).*

*a*1. Blackish granular magnetites, massive to semi-schistose, fine to coarse grained, compact to friable—39, 40, 41, 42.

*a*2. Cryptocrystalline, compact, tabular, schistose, sometimes containing actinolite—17?

b. *Poor in iron, rich in quartz, (magnetic rocks). Most abundant in the Marquette Region, especially in the western part; also abundant in the Penokie (Bad River) series.*

*b*1. Banded, arenaceous quartz and magnetite layers—52.

*b*2. Intimate mixtures of magnetite (with hematite) and quartzose matter, often cherty. Magnetic siliceous schist (flag ore)—23, 15. Both varieties graduate into ferruginous quartzytes.

c. *Ferruginous rocks, rich in amphibole,—the iron-oxide mostly magnetic. (Here are embraced such anthophyllite schists as are rich in iron.) Tolerably abundant in the Menominee Region.*

*c*1. Banded quartzose, amphibolic (mostly anthophyllitic, according to Brush), magnetic schists—130, 17. According to Dr. Wichmann the iron-ore at Penokie Gap is a related variety —148.

*c*2. Manganiferous anthophyllitic magnetite schists—*58*. Only in western part of the Marquette Region, constituting bed XVII.

*c*3. Garnetiferous anthophyllitic magnetite schist (eklogyte) —*27*. Only in one bed in the Marquette Region.

(B.) *Specular Hematites, Martites, and siliceous, jaspery, argillaceous Hematitic rocks.* Most abundant and typical in the eastern part of the Menominee Region.

a. *Rich in iron.*

*a*1. Granular, massive to semi-schistose, specular hematite and martite. Usually contain a little magnetite. Not so abundant as the magnetites of corresponding structure—5.

* See my Michigan Report, vol. i, chap. x, 1873.

*a*2. Chloritic, semi-schistose, specular ores, not abundant, —43.

*a*3. Specular-iron schists, often slaty, and passing into micaceous-iron varieties (the most abundant form of hematite)—38, 45, 47, 48.

*a*4. Micaceous-iron slaty schist; graduates into the last, *a*3. When interstratified with magnetic ore, it usually contains magnetite—46, 49.

*a*5. Kaolinic specular schist—2, 44. Rare and observed only in the eastern part of the Marquette Region.

*a*6. Purplish to pigeon color, shaly to sandy, generally rich in iron, dull specular ore—136, 67. Confined to the eastern part of the Menominee Region.

b. *Quartzose specular Hematites, poor in iron, poor in quartz. Abundant. Graduates into hematitic quartz schist.*

*b*1. Banded, micaceous-iron, quartzose schist—16, 32, 33. Abundant in the Marquette Region.

*b*2. Banded specular-iron with jaspery quartz ("mixed ore"), the laminæ often plicated and faulted to the extent sometimes of producing a breccia. Abundant with specular ores in the eastern part of the Marquette Region—*37*. Similar but more jaspery and less ferruginous rocks occur in the Black River series—84.

*b*3. Intimate mixture of specular hematite (often magnetic) with quartzose matter, often cherty. Hematitic siliceous schist (flag ore). Very abundant—68, 19, 36. Sometimes contains grains, apparently of decomposed garnets (bird's-eye ore)—6.

c. Hematitic argillaceous, hydro-magnesian and micaceous schists, sometimes graduating into limonitic varieties, and usually associated with rich iron-ore. Poor in iron; generally diffused, but not abundant. Included under varieties of clay and chloritic slate and mica schist.

(C.) *Limonitic Quartzose Ores and Rocks, often containing hematite and manganese.* Usually some shade of dull brown, generally soft and more or less earthy. Often contain ochre and kaolin (Brush), and probably turgite. Appear to be of the nature of residual deposits, from the partial dissolving out of the silica and the hydration of the iron of quartzose hematites.

a. Rich in iron ("soft hematite ores"). Most abundant in the Marquette Region, although absent from the magnetic district about Lake Michigamme. Also found in the Menominee Region.

*a*1. With little or no manganese—34, 35. A hard, red variety, rich in iron, and containing four per cent of water occurs in the Menominee Region—135.

*a*2. Richer in manganese (specimens of pure pyrolusite being sometimes found)—24, 25.

b. Poor in iron, rich in quartz, often ochrey. Graduates into limonitic quartz schist. A very siliceous variety of the two prevailing kinds in which a less proportion of the silica seems to have been dissolved out—26, 57. Generally diffused but not abundant. Was not observed in the Penokie series.

3. CALCAREOUS ROCKS.—CARBONATES AND SULPHATES.

1. *Uncrystalline Limestones.* Not observed.

2. *Crystalline Limestone.*

Tolerably abundant, especially in the Menominee Region. Usually dolomitic. In the Marquette Region it is always associated with quartzyte, and contains interstratified beds of clay slate (novaculyte) with oblique cleavage.

(1.) *Granular Limestone*—rare. Ferruginous—97; very rare, probably a vein. Brown, micaceous—144; observed at one point in the Marquette Region.

(2.) *Dolomyte and Dolomitic Limestone.**—Most if not all the limestones in beds contain more or less carbonate of magnesia.

The prevailing variety is light-grayish, sometimes mottled, fine-grained, semi-schistose, often containing quartzose laminæ, which project on weathered surface (ribbed)—9, 66, *143*. A crystalline, medium to coarse grained massive variety, free from quartz:—white in the Menominee Region, where it is most abundant; sometimes salmon-colored in the Marquette Region—11. White crystalline dolomyte, holding numerous crystals of tremolite, and, according to Dr. Wichmann, of wollastonite (142), occurs in the northeast part of the Menominee Region.

Siliceous; besides the variety banded with quartz laminæ, is one in which the quartz exists in grains, appearing on the weathering surface almost like sand,—*141*. It occurs midway between the Marquette and Menominee Regions. Argillaceous, in thin beds, at Lake Antoine, Menominee Region.

(3.) *Consisting of Sulphate of Lime.* Not observed.

4. IGNEOUS OR ERUPTIVE ROCKS.

(Including those metamorphic rocks which in a plastic state have been forced into adjacent cracks, thus taking the form of eruptive rocks).

1. *Feldspathic Series.*

(1.) Granite dykes or veins have been observed only in the Lower and Upper Huronian of the Menominee Region. Red ferruginous granite in iron-ore at two points—96. Gray granite

* Dr. Credner erroneously assigns certain dolomytes and conglomerates to the Laurentian. See Zeitschrift der deutschen geologischen Gesellschaft, xxi Band 1869, p. 516. Marbles, so abundant in the Laurentian of Eastern Canada have not as yet I believe been observed in that system as developed south of the lake.

in the hornblende and mica schists of bed XIX, at the contact with the overlying granite bed.

Granite dykes are very numerous in the Laurentian.

2. *Hornblende and Pyroxene Series.*

Some geologists would include here a considerable portion of the bedded greenstones embraced under metamorphic rocks.

"Trap"-dikes in a bed of magnetite occur at the Washington mine. At a few other points very small ones have been seen. Black, fine-grained, massive, hard, tough. Has been called doleritic, dioritic, and, by Dr. Wichmann, diabase. (Has but little resemblance to the bedded rocks so-named)—*79*, 94. The greenstone dikes, sometimes of great thickness, so numerous in the Laurentian, are not so fine-grained and are more dioritic in character.

3. *Hydrous Magnesian Schistose Rocks.*

These are found in dyke-like masses crossing quartzytes, iron-ores, and greenstones, sometimes apparently formed from the abraded material of the walls of a fault,*—73. Sometimes the rock is erratic, as in the case of the soft chloritic? schist dyke in massive quartzyte at the northeast corner of Teal Lake. Not observed in the Laurentian.

Dresden, Saxony, Dec. 21, 1875.

ART. XXVI.—*Seventh Catalogue of New Double Stars;* by S W. BURNHAM.

THE double stars in the following list have been discovered during the past year with the Clark & Sons 6-inch refractor previously used in these observations. The six catalogues preceding this will be found respectively in Monthly Notices of the Royal Astronomical Society for March, May and December, 1874, June and November, 1875, and Astronomische Nachrichten, No. 2062. The reference number in the first column is continued through the series.

Four pairs from the old double star catalogues have been found to be again more closely double. These are:

σ 39
H 4935
$\mathfrak{H}$ III. 113 (=Σ 2630 *rej*)
H 1489

Through the kindness of the distinguished observer, Baron Dembowski, I am enabled to attach his careful micrometrical measurements of a few of these objects.

* Faults of any great magnitude are rare in the Huronian.

No.	Designation.	R. A. 1880.	Decl. 1880.	Pos.	Dist.	Mags.
		h m s	° ′	°	″	
391	B.A.C. 10	0 3 14	−28 39	110·±	0·7 ±	6·0...6·0
392	B.A.C. 46	0 10 31	+60 52	...	20· ±	6.0..11·8
393	L 291	0 12 12	−21 48	30·±	0·5 ±	7·0...9·0
394	L 678	0 24 14	+46 52	300·±	1· ±	8·0...8·0
395	Ceti 82	0 31 9	−25 26	135·±	0·5 ±	6·0...6·0
396	B.A.C. 282	0 56 13	+60 26	85·±	1· ±	6.0..11·0
397	L 1943	1 0 53	+46 12	160·±	10· ±	8·0..10·5
398	O². Arg 1200	1 4 52	+47 10	60·±	2· ±	8·0...8·0
399	Ceti 211	1 21 46	−11 31	301·2	1·49	6·5..10·0
400	W¹III. 50	3 5 18	− 4 16	45·±	15· ±	7·0..11·5
401	W¹III. 830	3 44 10	− 1 52	260·±	4· ±	7·0..11·0
402	W¹IV. 318	4 17 3	− 1 33	75·±	5· ±	8·5..10·5
403	W¹IV. 379	4 19 18	− 2 20	100·3	2·00	7·0...8·5
404	Arg(8°) 805	4 49 51	+ 8 58	113·4	1·49	9·0...9·5
405	W¹V. 1045	5 42 22	−13 34	150·±	10· ±	8·5..11·0
406	W¹V. 1068	5 43 1	−13 28	260·±	8· ±	9·0..12·0
407	W¹VIII. 1159	8 45 50	− 6 20	160·±	6· ±	8·0..10·0
408	R 2231	8 48 58	+63 54	350·±	2· ±	7·0..10·0
409	W¹VIII. 1383	8 54 55	− 8 43	180·±	10· ±	8·0..10·0
410	B.A.C. 3127	9 4 30	−25 19	160·±	1·5 ±	7·0...9·0
411	Lac 4360	10 30 25	−26 3	310·±	1·3 ±	7·0...9·0
412	L 22722	12 2 10	−17 55	160·±	1·5 ±	8·0...9·5
413	Lac 5686	13 42 15	−27 46	110·2	77·7	6·8..10·0
414	Centauri 315	14 34 42	−30 25	160·±	1· ±	6·5...6·5
415	O². Arg 15675 A and B	15 44 50	+65 57	336·8	12·72	8·5..11·5
	A and C			357·6	30·82	12·0
416	Scorpii 155 A and B	17 10 46	−34 51	240·±	1·8 ±	6·0...8·5
	A and C			130·±	15· ±	10·0

391. This is κ' Sculptoris of some of the star catalogues.

393. Very difficult.

395. B.A.C. 160, magnitude 6.

396. A pair of the most extraordinary difficulty, very close and unequal. Not an easy test for a large aperture. Heis gives this as naked-eye star.

397. There is but little doubt this is the pair observed for H 2015, but error of 1° in Herschel's declination. There is nothing in his place.

399. The small star was suspected in Dec., 1873, but not verified until two years later. Measured by Dembowski (1876·07). There is a very distant companion in the direction of 67° which makes the pair σ 39.

402. Found in looking for Σ 547, the companion of which was invisible; so noted by Dembowski in 1865.

403. Measures by Dembowski (1876·07).

404. Found in verifying a suspected error of 1^m R. A. in 0Σ 90. Measures by Dembowski (1876·07.)

405. This and the next following were found in looking for Σ801 *rej.*

408. In Argelander 6·7^m.

411. A naked-eye star according to Heis.

413. Not properly a double star, but inserted for its remarkable red color. Dembowski calls it "perfect blood red." Most of the red stars of this class are smaller, and not so strongly marked. The small star appeared decidedly blue. My approximate measures of angle and distance. Not in Schjellerup's Catalogue of Red Stars.

415. Measures by Dembowski (1876·39).

416. A and C make the double star, H 4935. Close pair easy, although very low.

No.	Designation.	R. A. 1880.	Decl. 1880.	Pos.	Dist.	Mags.
		h m s	° ′	°	″	
417	L 32929	17 52 13	+39 27	270·±	1·5±	8·0...9·5
418	O². Arg 17847	18 1 28	+64 26	240·±	10· ±	8·5..11·5
419	L 34259	18 25 42	− 7 55	40·±	1·5±	8·0...9·5
420	W²XVIII. 722	18 25 53	+37 5	280·±	1·5±	8·5..10·0
	A and B					
	A and C			200·±	20· ±	11·0
421	W²XVIII. 1452	18 48 3	+43 15	270·±	1· ±	8·5...9·0
	A and B					
	A and C			230·±	30· ±	9·0
422	O¹. Arg 19281	19 7 34	−18 16	50·±	8· ±	8·5..11·5
423	O¹. Arg 19560	19 20 17	−29 44	110·±	1·2±	8·0...8·5
424	W²XIX. 676	19 23 5	+35 49	60·±	2·5±	8·5..10·0
425	L 38087	19 52 15	+19 58	241·1	1·33	8·5...8·7
426	O². Arg 19938	19 59 13	+54 18	140·±	6· ±	8·0..10·0
427	O². Arg 19952	19 59 28	+54 20	160·±	3· +	8.0..10·0
428	Arg(12°)4226	20 1 7	+12 36	346·4	0·52	7·2...8·0
429	L 38521	20 1 27	+35 27	30·±	7· ±	7·5..11·5
	A and B					
	A and C			301·0	10·79	10·0
	A and D			90·±	25· ±	11·0
	A and E			28·2	36·52	9·0
430	Arg (35°) 4008	20 6 48	+35 28	30·±	1· ±	9·0...9·0
	A and B					
	A, B and C			55·1	20· ±	9·5
	=H 1489					
431	W²XX. 530	20 15 25	+35 53	240·±	0·5	8·0...8·5
432	W²XX. 698	20 20 13	+35 23	220·±	1·2	8·0...10·0
433	Arg (50°) 2399	20 23 36	+55 55	220·±	6· ±	9·0..11·0
	A and B					
	A and C			250·±	20· ±	10·5
434	W²XX. 941	20 28 4	+41 27	100·±	1·2±	8·5...9·0
435	L 39867	20 33 14	+14 35	112·5	2·95	8·0..11·0
436	O².Arg. 23612	22 6 44	+57 21	340·±	15·±	8·0...10·8

417. In the field with Σ2246.

419. Found in looking for one of Herschel's suspected pairs, H 5496.

425. Measured by Dembowski (1875·72). He has detected a very minute companion about 10″ following, which I failed to see.

426. In the same field with No. 427, the two forming with a third 8ᵐ star a small triangle.

428. Close and difficult. The wide pair of small stars in the field is H 1476. The large star is rather strangely wanting in all the other Star Catalogues I have access to. Measures by Dembowski, two observations (1875·73).

429. The companions B and D are new. A, C and E make H III. 113= Σ 2630 *rej.* = Sh 314. Given with Herschel's measures (1783·7). In a splendid field.

430. As a wide pair this is H 1489, entered by Herschel, 236°·3 : 13″± : 9-10..10. There is probably an error of 180° in his angle, as the preceding star is obviously the largest, and so in Argelander who noted the magnitudes as 9·3 and 9·5. By a rough measure I found 55°·1, showing no material change has occurred since 1828. From the faintness of the components, the close pair is a very difficult object under ordinary conditions.

431. Very difficult.

433. Found in trying to identify H N. 89.

435. About 26′ *sf* β Delphini. Measures by Dembowski (1875·76).

Chicago, July 27, 1876.

ART. XXVII.—*An account of a New Meteoric Stone that fell on the 25th of March, 1865, in Wisconsin, identical with the Meno-Meteorite;* by J. LAWRENCE SMITH, Louisville, Ky.

THE Wisconsin meteorite, which fell on the 25th of March, 1865, and is one of much interest, attracted no attention at the time of its fall outside of the immediate neighborhood where it was observed, a fact due to the comparatively sparsely inhabited condition of the country. It was brought to my attention only a few months ago by one living in the region not far from where it fell. He sent me a small fragment that had been presented to him, and so similar was it in its appearance to the Meno-Meteorite that fell in 1861, that, not having heard of any fall at the period when this one was said to have been found, I considered it at first a fragment of that rare meteorite which had found its way to that part of the country. But on further inquiry and search I was soon satisfied that it was a piece of an undescribed meteorite; I have designated it the *Claywater* meteorite.

The following is the account I have been able to gather in relation to its fall.

In Vernon County, State of Wisconsin, about lat. 43° 30′, long. 91° 10′, at nine on the morning of the 25th of March, 1865, a body was seen by several persons passing rapidly through the atmosphere, accompanied with a loud rumbling noise. It was luminous and showed flashes of light. Its course was from northwest to southeast, and it exploded at a supposed altitude of four miles. At the time that the small fragments were thrown off from the main body, a noise like the rolling of musketry was heard. The main body seemed to have a rotary motion, making about one revolution in two seconds of time.

The observer from whom the above facts were obtained, thinks that the main body did not fall but passed into space.

No fragments were found until about five days after the fall, when two were discovered, weighing in all fifteen hundred grams. The curves of the surfaces of these fragments would indicate that they had pertained to a mass having a diameter of about thirty centimeters. No data were obtained by which to calculate its velocity, but the observer already referred to says that it was variously estimated from fifteen to twenty-five miles per second. Of the two fragments that fell, one has been lost or destroyed; the other has been placed in my possession by Mr. Claywater, who made the observations already recorded, and to whom we are indebted for the preservation of what we have of this interesting meteorite; for it differs in its physical aspects from any yet observed in this country.

The fragment in my possession, and which is all that has been recovered from this fall, weighed seven hundred grams; about one-third of the surface was covered with a thick, dull black crust; the fractured surfaces are quite granular, and its structure porous; it belongs to the hard variety of meteoric stones. Examined with a glass the grains are of a dirty green color with a greasy aspect, and in some places have a globular structure. Particles of iron are disseminated abundantly through the mass, and particles of troilite are also visible.

Its specific gravity is 3·66 and it is composed of:

Stony matter	78·33 per cent.
Metallic particles	17·07 "
Troilite	4·60 "
	100·00

The stony matter treated with aqua regia furnished:

Soluble matter	47·20 per cent.
Insoluble matter	52·80 "
	100·00

The composition of these two portions are:

	Soluble.	Insoluble.
Silica	32·55	57·41
Protoxide of iron	30·40	9·50
Alumina	trace.	4·00
Magnesia	35·80	22·80
Lime		3·70
Soda	·60	2·01
	99·35	99·42

The metallic particles, completely separated from the stony portion, are composed of:

Iron	92·15
Nickel	7·37
Cobalt	·28
Copper, Phosphorus } very minute quantity; not estimated.	
	99·80

In regarding the above analyses, it is very evident that the meteorite is made up of:

Bronzite, with probably a little anorthite	41·35
Hyalosiderite (olivine)	36·98
Nickeliferous iron	17·07
Troilite	4·60

As I was not able to find any analysis of the Meno (Alt. Strelitz Mecklenburg) meteorite, which fell Oct. 1st, 1861, at midday, and as the physical aspects of the one just described

were so strikingly similar to those of the Meno, I was interested to ascertain the mineralogical and chemical relations of the two.

An examination was made of this last meteorite, the result of which is placed in contrast with those obtained from the Claywater meteorite.

	Claywater.	Meno.
Stony matter	78·33	77·76
Metallic particles	17·07	18·00
Troilite	4·60	4·24
	100·00	100·00
Stony part, soluble	47·20	48·70
Stony part, insoluble	52·80	51·30
	100·00	100·00
Stony part, analyzed as a whole.		
Silica	44·98	44·70
Protoxide of iron and alumina	21·95	22·26
Magnesia	29·30	28·97
Lime	1·80	1·85
Soda	1·32	1·20
	99·35	98·98
Metallic particles.		
Iron	92·15	91·86
Nickel	7·37	7·53
Cobalt	·28	·13
Copper and phosphorus	traces in both.	
Specific gravity	3·66	3·65

It will be observed that the specific gravity of the Meno here given, is lower than that stated in Poggendorf's Annalen, cxvii, 637, it being there given as 4·1; but this must have been taken with a fragment containing some large particles of iron. My determination was made on two good average fragments, broken from a very fine specimen sent me by the late Wm. Nevill, of London, which were examined in my usual method, viz: after weighing the fragment to immerse it in water contained in a small vessel, and, placing this beneath the receiver of an air pump, thereby extracting all the air from the surface and cavities, and completing the process in the usual way.

In regarding the above comparative statement of the composition of these meteorites, it will be seen that the compositions of the two as made out by me do not differ more than those of two fragments of the same meteorite, while they both differ in their *physical aspects* from the ordinary type of meteorites, and, in fact, they have few or no parallels in the collections of these bodies; there are certainly none in mine, embracing stony meteorites representing over one hundred falls.

ART. XXVIII.—*Five new Variables, and a new Planet, found at the Litchfield Observatory of Hamilton College;* by C. H. F. PETERS.

RECENTLY the variability has been ascertained by me of stars in the following positions:

Right Asc.			Decl.		Max.	Min.
h.	m.	s.			mag.	
10	16	32	+14°	42′·7	10	∞
15	13	21	−19	53 ·0	6	10
16	0	19	−21	8 ·9	10	∞
20	6	15	−22	24 ·0	11	∞
21	0	32	−21	54 ·6	10	∞

The limits of magnitude given are gathered from only occasional notes taken during the later years. For fixing them more accurately, and also for determining the times of periodicity, more systematic and continuous watching would be required.

The positions refer to the equinox of 1860, which is the epoch of my manuscript charts.

A new planet, 11th magnitude, was found here last night (Aug. 9), of which I give to-day only the approximately reduced position:

Aug. 9, 1876. $10^h\ 34^m\ 27^s$.

$\alpha(165)=21^h\ 27^m\ 42^s$. $\delta(165)=-10°\ 0'\ 18''$.

The motion is nearly parallel to equator, perhaps slightly southward, 56^s in right ascension.

ART. XXIX.—*On the Relation of Franklinite to the Spinel Group of Minerals;* by GEORGE H. SEYMS. (Contributions from the Sheffield Laboratory, No. XLI.)

THE amount of iron in Franklinite, as shown by numerous determinations that have been made in the Sheffield laboratory, is subject to considerable variation. To determine whether this variation affects the general character of the mineral, and to supplement the recent investigations upon its composition and relation to the Spinel group, was the object in making the following analyses.

The first experiments were made on perfectly formed crystals, in a matrix of limestone, from Mine Hill. The analyses gave results which may be best expressed as follows:

	I.	II.	Mean.
SiO_2	·17	·17	·17
Fe_2O_3	63·42	63·38	63·40
Mn_2O_3	4·44	4·44	4·44
MnO	10·39	10·53	10·46
ZnO	23·11	23·12	23·11
	101·53	101·64	101·58

The relation of the metals to the oxygen, taking the mean of the two analyses, is given in the subjoined statement.

	Metals.	Oxygen.	
Fe_2	44·38	19·02	20·37
Mn_2	3·09	1·35	
Mn	8·10	2·36	6·92
Zn	18·55	4·56	

Dividing the amount of each element by its atomic weight gives as the ratio of the metals to the oxygen, R : O :: 3 : 3·999 $=R_3O_4$ nearly, or an oxygen ratio of the protoxides to the sesquioxides of 1 : ·981 or nearly 1 : 1, which corresponds to the formula of the Spinel group, $(R_2O_3+RO=R_3O_4)$.

The state of oxidation of the manganese here given was determined by solution of the mineral in HCl, and estimation of the clorine liberated, according to Bunsen's iodine method. Two experiments gave chlorine equivalent to ·47 per cent and ·43 per cent of oxygen, mean ·45, which requires the presence of 4·44 per cent Mn_2O_3.

The analyses following were made on a sample taken from an aggregation of imperfect crystals from Sterling Hill. While the crystals in the former case were but very feebly magnetic, these were strongly so, though they showed no signs of magnetite as an admixture.

	I.	II.	III.	IV.	Mean.
SiO_2	·08	——	——	·08	·08
Al_2O_3	·65	·65	——	..	·65
Fe_2O_3	67·43	67·50	67·32	67·42	67·42
FeO	15·68	15·62	——	——	15·65
ZnO	6·79	6·81	6·76	6·75	6·78
MnO	9·71	9·47	9·51	9·44	9·53
	100·31	100·16	99·97	99·99	100·12

This gives from the mean of the four analyses:

	Metals.	Oxygen.	
Al_2	·35	·30	20·53
Fe_2	47·19	20·23	
Fe	12·17	3·48	6·97
Zn	5·44	1·34	
Mn	7·38	2·15	

Deducing from this the atomic ratio of the metals to the oxygen we have as a result R : O :: 1 : 1 331 or as 3 : 3·994 = R_3O_4, and we find the oxygen ratio of the protoxides to the sesquioxides to be as 1 : ·981 or nearly 1 : 1.

The amount of iron protoxide shown in these results was found directly in the usual way by potassium permanganate.

As it has been stated that some varieties of franklinite give with HCl a solution containing $FeCl_2$, and at the same time evolve chlorine, this variety was quantitatively tested by Bunsen's method with a negative result. Careful experiment failed also to show any iron protoxide in the variety first analyzed. In both cases, therefore, the total amount of oxygen may be said to be fairly determined.

The results of these analyses give in both cases a ratio very nearly corresponding to that of spinel, notwithstanding the great differences in the relative amounts of the iron, zinc and manganese.

April 6th, 1876.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Thermic formation of Ozone.*—Berthelot has studied thermo-chemically the formation of ozone. Pure and dry oxygen was passed through a tube, where it was subjected to the influence of the silent electric discharge, and then into a calorimetric flask containing 500 c.c. of a solution of arsenous acid in hydrochloric acid, previously titered. At the end of twenty to thirty minutes, six to nine liters of oxygen had passed through the calorimeter, and its temperature had been raised one-third of a degree. By passing the oxygen current alone through the apparatus under the same conditions for an equal time, both before and after the experiment, the thermal data were rendered complete. The arsenic solution was treated with a graduated solution of permanganate in excess, and then titered back with a standard solution of oxalic acid. In this way the amount of arsenous acid oxidized and therefore the amount of ozone absorbed, was determined. In two experiments, the oxygen absorbed was 30·3 and 51·9 milligrams, corresponding to 90·9 and 155·7 milligrams of ozone; the heat set free being 118·2 and 223·7 calories respectively. Whence for one molecule, 48 grams, the heat is equal to +68·8 calories. Subtracting from this the heat produced in the oxidation of a molecule of arsenous acid, determined by Favre and by Thomsen to be +39·2 calories, we have +29·6 calories for the heat set free by conversion of one molecule of ozone into oxygen, and of course −29·6 calories in the reverse

process. This value is one-half greater than that given in the formation of the same volume of nitrogen monoxide or of chlorine monoxide, in both of which the value is −18. It is two-thirds of that given in the formation of nitrogen dioxide −43·3. In the three cases of direct synthesis of compound gases under the influence of electricity, the author finds:—

$O_4 + O_2 = (O_3)_2$ (4 volumes)—29·6 cal. (spark or silent discharge).
$N_2 + O_4 = N_2O_4$ (4 volumes)—24·3 cal. (spark).
$C_4 + H_4 = (C_2H_2)_2$ (4 volumes)—64· cal. (electric arc),—

an obvious proof of the function of electricity in chemical synthesis. Ozone therefore is a body in whose formation heat is absorbed, and the activity of which is due to this heat, which is again set free when it combines. It is thus a magazine of energy stored up under the influence of electricity. This is notable when it is remembered that it is condensed oxygen; condensation generally setting free heat.—*C. R.*, lxxxii, 1281, June, 1876.

G. F. B.

2. *On Hydrogen antimonide or Stibine.*—Owing to the difficulty of freeing stibine from hydrogen, and to the fact that it spontaneously decomposes even at ordinary temperatures, its exact composition has never been ascertained. Jones has examined the question anew and has obtained results which are closely approximate. The method he preferred for preparing the gas was to allow a strong solution of antimony in hydrochloric acid to drop on a considerable bulk of zinc either granulated or in powder. Chancing to observe the ready action of the gas on sulphur, according to the reaction

$$(SbH_3)_2 + S_6 = Sb_2S_3 + (H_2S)_3$$

the author made use of the fact in order to analyze it. The dry gas was passed through weighed U-tubes containing sulphur, then through a calcium chloride tube, and then through a strong solution of copper acetate. The apparatus being placed in sunlight (the reaction not taking place in the dark) it was found that a secondary reaction took place between the stibine and the hydrogen sulphide $(SbH_3)_2 + (H_2S)_3 = Sb_2S_3 + (H_2)_6$. By screening the empty portions of the tubes the quantity of sulphide thus formed was lessened; and by allowing for it, the amount of hydrogen combined with 122 parts (one atom) of antimony was found to be in two experiments, 3·34 and 3·13 respectively; whence the author concludes upon SbH_3 as the correct formula of stibine. He found the reaction of this gas on sulphur so delicate a test for the presence of light that he made some photometric and photographic experiments with it. It is an excellent test for antimony.—*J. Chem. Soc.*, clxi, 641, May, 1876. G. F. B.

3. *Compounds of Columbium and Tantalum with Nitrogen and with Carbon.*—Joly has made a series of experiments on the compounds formed by reducing at high temperatures oxides of columbium and tantalum in carbon crucibles. A mixture of

columbic oxide, sodium carbonate and pure carbon thus heated to whiteness, affords a crystalline mass of an olive color and friable. Heated to the temperature of fusion of nickel for six or seven hours, long violet-gray brilliant needles are obtained, which analysis showed to be a mixture of columbium carbide and nitride. The product formed at the temperature of fusion of steel contained $\frac{2}{3}$ of a molecule of the latter to one of the former; when heated for a longer time $\frac{4}{5}$ of a molecule; and that formed at the temperature of fusion of manganese, $\frac{1}{5}$ to 1. Tantalic acid thus treated acts similarly except that the carburation may be carried higher; one product, of a beautiful bronze-yellow color, obtained at the temperature of melted steel, containing only 0·7 per cent of nitrogen. —*Bull. Soc. Ch.*, II, xxv, 506, June, 1876. G. F. B.

4. *New mode of effecting the Substitution of Chlorine or Bromine in Organic Compounds.*—Damoiseau has called attention to the remarkable way in which carbon facilitates the introduction of chlorine and bromine into organic compounds. The form of carbon he prefers is obtained by calcining a mixture of dried blood and potassium carbonate, and subsequent washing and igniting. If the animal charcoal thus prepared be placed in a tube heated to 250° to 400°, and a mixture of chlorine with, for example, ethyl chloride gas be passed through it, abundant white fumes of hydrochloric acid appear, and oily drops collect on the walls of the tube. By varying the proportion of the two gases, monochlorinated, dichlorinated, trichlorinated, tetrachlorinated or finally perchlorinated ethyl chloride may be obtained singly and almost pure. Other chlorides act similarly. With bromine the effect is even greater. It is remarkable that if the tube be filled with pumice, wood charcoal, alone or platinized, or even with platinum sponge itself, the effect is insignificant.—*C. R.*, lxxxiii, 60, July, 1876. G. F. B.

5. *On Physical Isomerism.*—In studying nitrometachlornitrobenzene, Laubenheimer has discovered an excellent example of physical isomerism. To prepare this substance, metachlornitrobenzene was treated with a mixture of fuming nitric and sulphuric acids with the aid of heat. On pouring the whole into water, a yellow oil fell down, which almost entirely solidified to a crystalline mass on cooling. On investigation it appeared that this nitrometachlornitrobenzene existed in four distinct modifications, physically isomeric, three of which were solid, the other liquid. The first or α-modification is obtained by dissolving the crude product in warm alcohol and allowing it to cool. An oil separates at first, in which after some time crystals appear which by repeating the operation become large thick prisms. Any of the other forms when melted, crystallize in this form on introducing a fragment of it, as the liquid cools. The crystals are monoclinic twins with a well-defined cleavage, in which $a:b:c=1{\cdot}8873:1:0{\cdot}9810$ and $\gamma=114°\ 14'$. The plane of the optic axes is perpendicular to the plane of symmetry. Angle between them $45°\ 31'$ for Na light. Double refraction strong and negative. Fusing point

36·3°. The second, or β-modification is obtained by fusing the first completely at a temperature of 39° to 40°, and allowing to cool. Long concentric groups of thin prisms are in this way obtained. Crystals of α, after five weeks, yield β on crystallization from alcohol. Either of the varieties fused and allowed to cool yield β on introducing a crystal of this form. It also is monoclinic but without cleavage. The axis-ratio $a:b:c=0{\cdot}6249:1:0{\cdot}5600$ and $\gamma=91°\ 27'$. Its fusing point is 37·1°. The third or γ-modification crystallized from the aqueous solution into which the mixture was poured in preparing the substance. It is also the most permanent form of them all, both α and β crystals becoming turbid in twenty-four hours and being completely converted into γ in a few weeks. The crystals are orthorhombic, show a distinct cleavage, and have a moderate, positive double refraction. The angle between the optic axes is for sodium light 47° 17′. The fusing point is 38·8°. The fluid modification was obtained by heating any of the other forms to 42°. On cooling the substance remained permanently fluid, though a fragment of either solid form caused crystallization at once. The author explains this isomerism on the hypothesis of Naumann, that physical molecules are aggregations of chemical molecules, and that the stable molecules are composed of a larger number of chemical molecules than the unstable. Hence the fusing points of the latter are lower, the specific gravity is less and the specific heat is greater. —*Ber. Berl. Chem. Ges.*, ix, 760, June, 1876. G. F. B.

6. *Synthesis of Allantoin.*—As pyruvic acid acting upon urea gives a homologue of allantoin, Grimaux acted upon urea with glyoxylic acid in expectation of obtaining allantoin itself. One part of glyoxylic acid was heated to 100° with two parts of urea for eight to ten hours. The mass was extracted with boiling alcohol, and the residue was dissolved in twelve to fifteen times its weight of hot water. On cooling beautiful crystals were deposited, which gave on analysis the formula $C_4H_6N_4O_3$, a glyoxylic diureide. Its identity with allantoin was completely proved by its chemical reactions, by its solubility, by its crystalline form, etc. The rational formula

$$\begin{array}{l} CH\diagup NH-CO-NH_2 \\ \quad\ |\ \ \diagdown NH\diagdown \\ CO-NH\diagup\ \ CO \end{array}$$

is assigned to it by the author.—*C. R.*, lxxxiii, 62, July, 1876. G. F. B.

7. *High Pressure Manometer.*—M. L. Cailletet, in a recent examination of the change of volume which a cylindrical reservoir of glass undergoes, found this change exactly proportional to the pressure. Experiment carried to the point of fracture showed that this law held at even the highest pressure, and that moreover the glass underwent no permanent change in shape. An extremely simple manometer is based on this principle. It consists of a sort of glass thermometer whose cylindrical reservoir is enclosed in spherical cups and filled with colored liquid or mercury. The capillary tube is calibrated with care and is

enlarged at one point so that it may be attached to the reservoir by gutta percha passing through a copper orifice. The latter is then closed by a screw surrounding the tube. Liquid being pressed into the outer reservoir compresses the glass and causes the mercury to rise in the tube by an amount proportional to the pressure.

It is indispensible that the temperature of the apparatus should be constant, which is easily accomplished by surrounding it with water or melting ice. In rapid determinations even these precautions are needless. It is only necessary to take care before applying the pressure to see that the level of the liquid coincides with the zero of the graduated scale. If this is not the case the scale should be raised or lowered to the proper position. By varying the relative dimensions of the tube and reservoir any desired sensibility may be attained. A comparison of this instrument with the open-air manometer of the College of France shows that the liquid displaced by the diminution of the glass envelope rises to a height exactly proportional to the pressure exercised upon its walls. In fact this should be so, for if we take for abscissas the pressures and for ordinates the volumes of the peizometer, the compressibility of the glass being very small this volume changes but little, so that for very different pressures p and p', the volumes v and v' differ but little; consequently the curve, whatever it may be, will approach very nearly to a straight line. Consequently the change in volume of the reservoir ought to be proportional to the increase in pressure, and this within very wide limits, provided the change in volume is small.—*Journ. de Phys.*, v, 181. E. C. P.

8. *Waves on Lake Geneva.*—Dr. Forel gave the London Physical Society an account of some interesting observations which he has recently made on the periodic waves which take place on the Swiss Lakes and are there called "Seiches." It has long been observed that the waters of most of these lakes are subject to a more or less regular rise and fall, which at times has been found to be as much as one or two meters. Dr. Forel has studied this phenomenon in nine different lakes, and finds that it varies with the length and depth of the lake and is in every way analogous to that already studied by Prof. Guthrie in artificial troughs, and follows the laws which he has deduced from his experiments. Most of the observations in Switzerland were made on the Lake of Geneva, but that of Neuchâtel was found to be best fitted for the study of the subject, possessing as it does an extremely regular geometric form. The apparatus he employed was very sensitive to the motion of the water, being capable of registering the waves caused by a steamboat half an hour after it had passed and five minutes before its arrival, and was so constructed as to eliminate the effect of common waves, and to register the motion side by side with a record of the state of the barometer, on paper kept in continuous motion. While he found the duration of waves to be ten minutes at Monges it was seventy

minutes at Geneva, and this is explained by the narrowness of the neck of the lake at the latter place. This period he proved to be independent of the amplitude, and to be least in the shortest lakes. For shallow lakes the period is lengthened, and his observations show that the period is a function of the length and depth and that longitudinal and transverse waves may coexist, just as Prof. Guthrie has shown to be the case in troughs.—*Nature*, xiv, 164. E. C. P.

9. *Friction of the Ether.*—Mr. W. M. Hicks drew the attention of the Cambridge Philosophical Society to some experiments of Messrs. Stewart and Tait on the heating of disks by rapid rotation in vacuo, and which they referred to the friction of the ether. He showed that it was not necessary to have recourse to this explanation, that nearly all the effects could be accounted for if it is supposed that the disc, through the rapid rotation, has expanded and consequently been lowered in temperature, that whilst rotating it is raised to the temperature of the surrounding region, and, therefore, when the rotation is stopped, and the disc has shrunk to its former size, it will give out the heat it had taken in whilst rotating. In the case of silver it was shown that the disc ought to show a rise of ·4°C., if the rotation had been continued for some time, and this was compared with the rise of ·47°C. which Messrs. Stewart and Tait had observed in an aluminum disc, thus showing that the effect was of the same order of magnitude in the two cases. It was also shown that if the whole heating were due to ethereal friction, that this friction would be ·0006 lbs. per square foot, and that if we suppose this amount to act on the surface of the earth, the day would be lengthened in the course of a century by something like ·006″.—*Nature*, xiv, 144. E. C. P.

10. *Specific heat of Gases.*—M. M. Kundt and Warburg have determined experimentally the ratio of the two specific heats of mercury vapor which has been supposed by chemists to consist of monatomic molecules. According to the Kinetic theory of gases, supposing the gaseous molecule to consist of only one atom, the relation of the two specific heats (as Clausius has shown) would be 1·666. The lower number obtained by experiment for several gases may probably be explained by the complete constitution of their molecules. The method here employed was to produce a sound in two glass tubes placed end to end, and containing, one mercury vapor, the other air. Having introduced powder into the tubes they observed the distances between the nodes of vibration. Applying the formula for the velocity of sound which includes the densities, temperatures, and the ratio of the specific heats, and taking as the value of this ratio in the case of air, the number 1·405, they obtain, for mercury vapor the number 1·67, which may be considered as fully in accord with the number 1·666 furnished by theory.—*Pogg. Ann.*, iii, 1876. *Nature*, xiv, 182. E. C. P.

II. Geology and Mineralogy.

1. *Geological Survey of Canada;* Alfred R. C. Selwyn, F.R.S., Director. *Report of Progress* for 1874–75. Montreal. 320 pp. 8vo. 1876.—This report consists of an introductory report by Mr. Selwyn; reports on the country west of Lake Manitoba and Winnepegosis, and on the geology of Lake Winnipeg, by Mr. R. Bell; on the country between the Upper Assineboine River and Lakes Winnepegosis and Manitoba, by Mr. J. W. Spencer; on explorations in British Columbia, by Mr. J. Richardson; on observations in New Brunswick, by Prof. Bailey and Mr. Matthew; on boring operations in New Brunswick, and on the iron ore deposits of Carlton Co., N. B., by Mr. R. W. Ells; on portions of Frontenac and Lanark Counties, and on the economic minerals, by Mr. H. G. Vennor; on explorations in Cape Breton, by Mr. C. Robb; on statistics of the trade and manufacture of Canadian salt, by Mr. J. L. Smith; on some Canadian minerals, by Mr. B. J. Harrington; chemical contributions, by C. H. Hoffmann. The reports contain much of value to science. We cite a few of the facts:

Glacial Striæ.—According to Mr Bell the glacial striæ on the east side of Lake Winnepeg, and between Lake Winnipeg and Lake Superior, run generally to the southwestward. This direction confirms the view, presented by the writer, that the great glacier had its maximum height above the sea-level between that region and the Atlantic coast along the area of greatest precipitation, and that it thinned down toward the continental interior.

Heights of Lake Winnipeg and others.—Mr. Bell states that the Canadian Pacific Railway Survey obtained, by a series of spirit levels carried all the way from the sea, for the height above sea-level of Lake Winnipeg, 710 feet; St. Martin's Lake, 737 feet; Lake Manitoba, 752 feet; Lakes Winnipegosis and Cedar, 770 feet; Lake of the Woods, 1,042 feet.

Mascarene Series of New Brunswick, Upper Silurian in age.—Messrs. Baily and Matthew in their report state that the so-called "Mascarene series" of Southern New Brunswick, containing diorytes, felsytes, argillytes, is of Upper Silurian age. It includes below, sandstones, and red, green, and purplish argillytes, affording on the southwest side of Passamaquoddy Bay numerous shells of the genera *Modiolopsis*, *Lingula*, and *Loxonema*; and above, diorytes, felsytes (the color usually brick red) and red slates. On the Mascarene shore the rocks have a thickness of about 2000 feet. The lowest division, consisting of about 400 feet of feldspathic slates, affords Upper Silurian fossils at Back Bay of La Tete Harbor, at Frye's Island and at Oak Bay. The next division, about 600 feet thick, is stated to afford remains of "*Cordaites*, a large *Cyclopteris*, probably a *Sphenopteris*, and a *Carpolite*, and striate and punctate stems of Ferns."

Analyses and Descriptions of Minerals.—Mr. Harrington gives

analyses of an aluminous pyroxene from Grenville; sodalite and natrolite, from felsytic dikes, intersecting Trenton limestones near Montreal; Chromiferous serpentine from Bolton or Melbourne; pyrrhotite of Elizabethtown; serpentine containing magnesite; feldspar of a dioryte, near anorthite; and Mr. Hoffmann, analyses of kaolinite; a Hisingerite-like mineral from Elizabethtown; a feldspar (labradorite) of a dioryte from North Sherbrooke; and a pyrite from Londonderry, Nova Scotia, besides analyses also of some mineral waters. J. D. D.

2. *Bulletin of the Geological and Geographical Survey of the Territories*, Dr. F. V. HAYDEN in charge. Vol. ii, No. 4, pp. 279–374 (closing the volume). Washington, August 4, 1876. Department of the Interior.—This new number of the Bulletin contains the following papers: Notes on the Geology of Northeastern New Mexico, by O. ST. JOHN; on Sexual, Individual and Geographical variation in *Leucosticte Tephrocotis*, and on geographical variation among North American Mammals, especially in respect to size, by J. A. ALLEN; on fossils from Vancouver's and Sucia Islands, and other northwestern localities, and on the New Genus, *Uintacrinus* of Grinnell, by F. B. MEEK. Mr. St. John treats of the Cretaceous and Tertiary strata of the region, the mesas of basalt, besides the general features of the valleys, parks and ridges, and illustrates his subject by admirable sketchy views, illustrating both the geology and scenery. He states that "the basin of the Canadian is partially surrounded on two sides by the immense basaltic-capped mesas, the flat summits of which rise 1,000 to 1,500 feet above its surface." The plain itself is everywhere traversed by dikes, the rocks of which are the same as those of the mesas. The Capulin country to the east of the Canadian has similar mesas of varying height; and all were once probably united. The basaltic layers usually overlie directly Cretaceous or Tertiary beds, and were ejected at the close of the Tertiary.

Mr. Allen shows that the individuals of the species of *Felidæ* of North America increase in size to the southward; of the *Canidæ* and *Procyonidæ* increase to the northward and decrease to the southward; of the *Ursidæ*, increase to the northward; of the *Sciuridæ*, and *Leporidæ* also increase to the northward or decrease to the southward; and he states the general conclusion—that the individuals are largest in the region "where the group reaches its highest development, or where it has what may be termed its center of distribution;" and "the most typical or most generalized representatives of a group are found near its center of distribution, outlying forms being generally more or less "aberrant" or "specialized." See for a further notice of Mr. Allen's memoir, by Prof. Verrill, page 238 of this volume.

Mr. Meek describes three Carboniferous species from the borders of Washington Territory near 49° north and 114° west, and several Cretaceous species from Vancouver's and the Sucia Islands. The paper is illustrated by six plates. Mr. Meek also describes

and figures specimens of the *Uintacrinus socialis* of Grinnell—a Cretaceous Crinoid,—and points out some characters that were not distinct in Grinnell's specimens.

3. *Report of the Exploring Expedition from Sante Fé, New Mexico, to the junction of the Grand and Green Rivers of the Great Colorado of the West*, in 1859, under the Commander, Capt. (now Colonel) J. N. Macomb, Corps Topogr. Engineers; with the *Geological Report* of Prof. J. S. Newberry, Geologist of the Expedition. Engineers' Department, U. S. Army. 148 pp. 4to.—This volume, excepting the first four pages occupied with the General Report of Colonel Macomb, is made up of the Geological Report of Prof. Newberry, a Paleontological report on the Carboniferous and Triassic fossils, by the same author, and another on the Cretaceous Fossils, by Mr. F. B. Meek. The text is illustrated by a number of excellent lithographs printed in colors, representing geological views, and the paleontological descriptions by eight plates of fossils.

The expedition was in the field during the summer of 1859; and the report of Dr. Newberry, its geologist, bears the date "May 1, 1860;" but the "breaking out of the rebellion" arrested its publication, and only recently was its printing ordered.

Dr. Newberry remarks that the region has since been the field of several exploring and surveying expeditions, and the subjects of their reports; so that the results he obtained have been partly anticipated. He has wisely, however, published his report as it was written, without reference to the later works. The report is therefore all the more valuable as independent testimony with regard to the geological structure of the country. It treats of the coal and the Coal-measures of Kansas, and the extension of the Carboniferous (Coal-measure) limestone westward; of the succeeding Permian, first met at Dragoon Creek; of the Gypsum formation (Triassic or Triassic and Jurassic) which overlies the Permian from the west side of Cottonwood Creek to Walnut Creek; of the Lower Cretaceous beds of Walnut Creek to Pawnee Fork; of the "Tertiary basin of the Arkansas," as Dr. Newberry had before designated it, whose western margin crosses the Santa Fé road west of the Pawnee Fork; and of the Tertiary, Cretaceous and other strata on the way to Santa Fé; of the Geology of the vicinity of Santa Fé; of the Geology of the route from Santa Fé to the Sierra la Plata, including a description of the boiling spring of Pagosa, 40 to 50 feet in diameter, in apparent ebullition from escaping gases, situated on the San Juan, up the valley between the Sierra San Juan and the Sierra del Navajo; on the Geology of the Sage-Plain and Valley of the Upper Colorado, with an account of the cliff habitations; and on the region of the San Juan. Dr. Newberry describes and figures Triassic plants (*Otozamites*, *Zamites*, *Pecopteris*, *Pterophyllum*, *Podozamites*, *Alethopteris*, *Camptopteris*, *Tæniopteris*, and *Jeanpaulia*) from Los Bronces or Yaki River, Sonora, and from the copper mines near Abiquiu, New Mexico, besides some Carboniferous and Cretaceous fossils;

and Mr. Meek, various Cretaceous species. Dr. Newberry mentions that a larger species of Jeanpaulia has been observed by him among the plants of the Triassic of North Carolina.

It is greatly to be regretted that the publication of this excellent volume has been so long delayed.

4. *Report of Explorations across the Great Basin of the Territory of Utah, for a direct wagon-route from Camp Floyd to Genoa in Carson Valley*, in 1859, by Capt. (now Colonel) J. H. SIMPSON, Corps Topogr. Engineer, U. S. A. Engineers' Department, U. S. A. 494 pp. 4to, with plates and maps. Washington, 1876. Containing a Geological Report of Mr. HENRY ENGELMANN; Paleontological, of Mr. F. B. MEEK; Ichthyological, of Mr. T. GILL, etc.—The explorations here recorded were made in 1859, and the report now published bears the date Febuary 5, 1861—the delay in publication having been occasioned by the civil war.

The volume is occupied chiefly by the observations of the Engineer corps—including, the results of astronomical, topographical, climatal, magnetic and other related investigations, tables of distances, altitudes and grades of routes; but contains also a history of the explorations of the Great Basin from the time of Father Escalante in 1776 to the present period, and a general description of the country, with Captain Simpson's Itineraries; also a Geological Report, occupying 92 pages, by Henry Engelmann, geologist of the expedition, a Paleontological Report, of 40 pages, by Mr. F. B. Meek; and Appendixes on the Birds, by Prof. Baird, on the Fishes, by Mr. T. Gill, on the Botany, by Mr. G. Engelmann, and on Eastern Utah and its Indians, by Dr. G. Hurt. The delay in the publication of Mr. Henry Engelmann's valuable report has lost him the credit of first discovery in many points connected with the geology of the region. It treats of the geology of Eastern Kansas and Southeastern Nebraska; of the plains next west, to the foot of the Rocky Mountains; of the district of the Rocky Mountains, between Fort Laramie and the South Pass; of the Green River Basin, and the region west to the axis of the Wahsatch Mts.; the district of Central and Western Utah, the so-called Great Basin. Mr. Meek's report gives descriptions and figures of Devonian, Carboniferous, Jurassic, Cretaceous and Tertiary fossils, the illustrations occupying five plates. The Ichthyological Report of Mr. Gill is accompanied by eleven lithographic plates, and the Botanical Report of Mr. G. Engelmann, by three plates, illustrating the species *Echinocactus Simpsoni* Engelm. and *Opuntia pulchella* Engelm.

5. *Fossil marine plants from the Coal-measures.*—Mr. LESQUEREUX, in the Report of the Indiana Geological Survey for 1875, has described three species of sea-weeds of the Lower Silurian genus *Palæophycus* Hall, from iron concretions in a bed of clay over coal L, on a branch of Salt Creek, Vigo County, Indiana; also others of the new genera *Asterophycus* from a sandstone connected with coal-beds near New Harmony, Indiana, and from the Lower Carboniferous, Rock Castle, Kentucky, and *Conostichus*, from Port Byron, Illinois and from Indiana.

6. *Remarks on Fossils from the Ashley Phosphate Beds.*—Prof. LEIDY observed that the so-called phosphate beds of Ashley River, South Carolina, were remarkable for the singular admixture of multitudes of fossils of different ages, from the early Tertiary period inclusive down to the present epoch. The phosphatic nodules, for which the beds are explored, appear to have had their origin from the Eocene rocks beneath. These have also contributed numerous remains of marine vertebrates, especially of squalodonts, reptiles, and fishes. Mingled in the sand and clay with the phosphatic nodules and bones of Eocene animals, are innumerable remains of cetaceans, sharks, and other marine animals of perhaps the middle and later Tertiary ages. Added to these are multitudes of remains of both marine and terrestrial animals of the Quaternary period. There are found pell-mell together bones of Eocene squalodonts, animals related to the whales and seals; hosts of teeth of the great shark *Carcharodon augustidens;* myriads of teeth of the giant of sharks of the Tertiary period, the *Carcharodon megalodon;* bones and teeth of whales and porpoises; and abundance of remains of elephant, mastodon, megatherium, horse, etc.; and occasionally the rude implements of our more immediate ancestors.

From among a collection of fossils from the Ashley phosphate beds, recently submitted to his inspection by Mr. J. M. Gliddon, of the Pacific Guano Company, the specimens were selected which lie upon the table. One of these is a well-preserved tooth of a Megatherium; another, a characteristic portion of the skull of a Manatee; a third, a complete tusk of the Walrus; indicating a still farther point south for the extension of this animal than had been previously known; fourth, a huge tooth of a cetacean allied to the sperm whale, probably the same as those from the crag of Antwerp ascribed to Dinoziphius. Besides these there are the beaks of three cetaceans of the little known family of the Ziphioids. These are porpoise-like animals, without teeth in the upper jaw, and usually with but a single pair of teeth in the lower jaw. The beaks, composed of the co-ossified bones of the face, are remarkable for their ivory-like density which probably rendered them available as weapons of defence.

A fourth beak from the same locality, presented by Mr. C. S. Bement, belongs to a different species of the same family. The beaks and some associated fossils will form the subjects of a paper shortly to be presented to the Academy.

The beaks have been referred to species with the following names and brief distinctive characters:—

Choneziphius trachops.—Supra-vomerian canal open. Intermaxillaries co-ossified and forming a crest along the middle of the beak extending to the interval of the prenareal fossæ. Maxillaries with a rugged tract at the upper part of the base of the beak.

Choneziphius liops.—Beak proportionately of less length than in the preceding. Supra-vomerian canal and intermaxillaries the

same, except that the crest of the latter in front is acute. Maxillaries without the rugged tract at base.

Eboroziphius cœlops.—A new genus as well as species. Beak above forming a broad gutter as in Hyperoodon, and not divided by an intermaxillary crest as in the preceding. Maxillaries with prominent lateral crests at base, convex inwardly. Right prenareal fossa occupied by a thick osseous disk. Intermaxillaries coossified. Supra-vomerian canal open.

Belemnoziphius prorops.—Beak solid, with all traces of the original separation of the constituent bones and the ossified mesethmoid cartilage obliterated.—*Proc. Acad. Nat. Sci., Philad.*, May 9.

7. *Fish Remains of the Mesozoic Red Shales.*—Prof. LEIDY remarked that the remains of life were rare in the Mesozoic red shales which cross Pennsylvania about fifteen miles north of Philadelphia. Hence any fossils whatever from these rocks were of interest. The three cycloid fish scales, and a few detached caudal rays, in the fragments of red shales, presented by him this evening, he found on the Perkiomen Railroad, near Yerkes' Station, Montgomery County. One of the scales resembles those described by the late Prof. E. Emmons, under the name of *Rhabdiolepis elegans*, from the mesozoic coal shales of Chatham Co., N. C.—*Proc. Acad. Nat. Sci., Philad.*, May 9.

8. *A Study of the Rhœtic Strata of the Val di Ledro, in the Southern Tyrol;* by T. NELSON DALE, Jr., Mem. Geol. Soc. de France. 70 pp. 8vo, with maps and sections. Paterson, N. J. 1876.—The author gives the results of his geological explorations in the Southern Tyrol, and illustrates his subject with a colored geological map and many sections.

9. *On the Mammalia and Traces of Man found in the Robin-Hood Cave;* by W. BOYD DAWKINS.—The author noticed the various species of animals discovered by Mr. Mello during the researches, the results of which are given in another paper, and drew certain conclusions from their mode of occurrence as to the history of Robin Hood's Cave. He considered that the cave was occupied by Hyænas during the formation of the lowest and middle deposits, and that the great majority of the other animals whose remains occur in the cave were dragged into it by the Hyænas. That they served as food for the latter is shown by the condition of many of the bones. During this period the red sand and clay of the lowest stratum was deposited by occasional floods. The red loam or cave-earth forming the middle stratum was probably introduced during heavy rains. The occupation of the cave by Hyænas still continued, but it was disturbed by the visits of Palæolithic hunters. The remains found in the breccia indicate that the cave was inhabited by man, and less frequently visited by hyænas than before. The presence of vertebræ of the hare in the breccia would imply that the hunters who occupied the cave had not the dog as a domestic animal. After a discussion of the relations of the animals forming the fauna of the cave, the author

proceeded to describe the traces of man found in it, which consist of fragments of charcoal, and implements made of antler and mammoth-tooth, quartzite, ironstone, greenstone and flint. The distribution of these implements in the cave represents three distinct stages. In the cave-earth the existence of man is indicated by the quartzite implements, which are far ruder than those generally formed of the more easily fashioned flint. Out of 94 worked quartzite pebbles only three occurred in the breccia, while of 267 worked flints only eight were met with in the cave-earth. The ruder implements were thus evidently the older, corresponding in general form with those assigned by De Mortillet to "the age of Moustier and St. Acheul," represented in England by the ruder implements of the lower breccia in Kent's Hole. The newer or flint series includes some highly finished implements, such as are referred by De Mortillet to "the age of Solutré," and are found in England in the cave-earth of Kent's Hole and Wookey Hole. The discovery of these implements considerably extends the range of the Palæolithic hunters to the north and west, and at the same time establishes a direct relation in point of time between the ruder types of implements below and those more highly finished above.—*Proc. Geol. Soc., in Ann. Mag. Nat. Hist.*, Aug., 1876.

10. *Evidences of Theriodonts in Permian Deposits elsewhere than in South Africa;* by Prof. R. Owen.—In this paper the author noticed some described Reptilia which he believes to belong to his order *Theriodontia*. In 1838 Kutorga described as probably mammalian the distal end of a humerus showing a perforation or canal above the inner condyle. The specimen was from the Permian of the Western Ural; and Kutorga gave it the name of *Brithopus priscus*. Under the name of *Orthopus primævus* he described the proximal part of the humerus of the same species, perhaps of the same bone. There is thus evidence of an extinct reptile in the Permian deposits of the Ural with a humerus showing the characters of the Theriodont reptiles of the Karoo series of South Africa. The British Museum possesses a cast of the first-mentioned fragment, labelled by Krantz "*Eurosaurus Uralensis*, H. von Meyer, *Brithopus priscus*, Kutorga." The genus *Eurosaurus* was founded in 1842, by Fischer von Waldheim, upon some fragments of bone, including a humerus with a broad proximal end as in Kutorga's *Orthopus;* and Fischer also noticed a humerus showing characters like those of Kutorga's *Brithopus*, from the same locality as the portion of a jaw described under the name of *Rhopalodon Wangenheimii* Fischer, which contained nine molar teeth, with thick, pointed, subcompressed crowns, with trenchant and serrate borders. In 1858 H. von Meyer described a skull from the Permian of the Ural, under the name of *Mecosaurus Uraliensis*, as a Labyrinthodont; and Eichwald referred this genus, with Kutorga's *Brithopus* and *Orthopus*, to Fischer's *Eurosaurus*. The author regarded *Mecosaurus* as truly Labyrinthodont; whilst the Permian forms constituting Kutorga's genus he referred to the Theriodont order. From

the same locality as the above, Kutorga describes *Syodon biarmicum* as probably a Pachyderm. Its teeth resemble those of *Cynodraco*. Eichwald's *Deuterosaurus biarmicus* is founded upon the fore part of both upper and lower jaws of a reptile, containing teeth with denticulate or crenulate trenchant borders, the canines being large, especially in the upper jaw. *Deuterosaurus* closely resembles *Cynodraco*, and still more the *Lycosaurus* of the Karoo beds of the Sneewberg range. All the above are from the Permian beds of the Ural; and the author regards them as furnishing suggestive evidence of the Palæozoic age of the Karoo series, in which the Theriodont reptiles are best represented.

The author further notices a Theriodont allied to *Lycosaurus*, from a red sandstone, probably of Permian [Triassic?] age, in Prince-Edward Island. The remains include the left maxillary, premaxillary, and nasal bones; the teeth, implanted in distinct sockets, have subcompressed, recurved, conical, pointed crowns, with minutely crenulated borders. The foremost tooth in the maxillary is a canine; and in other points the dentition shows Theriodont characters. This fossil has been described by Dr. Leidy under the name of *Bathygnathus borealis*. Thus, supposing the affinities of the fossils from the Ural and Prince-Edward Island to be correctly determined, the Reptilia distinguished by Mammalian characters are shown to have had a very wide range. Further, the author thinks that the Theriodont reptiles of the Bristol dolomitic conglomerate may also prove to constitute a family in the Theriodont order.—*Proc. Geol. Soc., in Ann. Mag. Nat. Hist.*, Aug., 1876.

11. *Silurian dioryte, chlorite slate and serpentine in Newfoundland.*—Mr. Howley's labors in Newfoundland during 1874 were, in accordance with Mr. Murray's plans, given to the survey, topographical and geological, of the western coast, about the peninsula and bay of Port-a-Port, and St. George's Bay. In tracing the Lower Silurian formations of the Newfoundland coast, Mr. Murray and his colleagues have been able to identify them with more or less precision as equivalents of the Quebec and Birdseye and Black River groups of Canada. But in the course of their surveys they have at different times encountered intercalated sheets of metamorphic rocks in the Lower Silurian series, overlying unaltered and fossiliferous strata. Thus, at Bonne Bay, in 1862, Mr. Richardson found highly metamorphosed rocks, including white talcose slates and serpentine, in some portion apparently of the Quebec group. Four years afterward Mr. Murray observed, farther south, in the Bay of Islands, that sandstones believed to represent the Sillery zone of the Quebec group passed below the serpentine of the Blowmedown Mountains. Mr. Howley has now confirmed and extended these observations by mapping the country between the Bay of Islands and St. George's Bay. He has traced Mr. Murray's serpentine rocks southward to Bluff Head, and finds that they pass unconformably over different horizons of rocks which are taken to represent the Sillery and Levis subdivisions of the Quebec group of the Lower Silurian system. The

striking character of this unconformable junction is well brought out upon the map, where two large cakes of the overlying rocks are seen to sweep over both anticlinal and synclinal folds of the lower formations. These cakes consist of brecciated dolomite or limestone, chlorite-slate, dioryte and serpentine, having a total thickness of perhaps 1,500 feet. Their exact geological horizon seems not yet quite satisfactorily fixed, but they are placed provisionally between the Sillery and Birdseye and Black River formations. Doubtless further details will be given in future reports regarding this remarkable feature of Newfoundland geology, and till they appear, it may be well to avoid any discussion of the theoretical aspect of the subject. It is not the first time that an instance has occurred of the higher rocks of a district being more metamorphosed than the lower, but there has probably never been observed so remarkable a case, for here the metamorphosed and contorted series is described as actually overlying unmetamorphosed strata.—*Notice of the Report on the Geological Survey of Newfoundland for* 1874, *in Nature of July* 20.

12. *Oldhamia in Wisconsin.*—In a letter to one of the editors of this Journal from Mr. J. W. Porter, dated Eau Claire, Wisconsin, June 12th, the writer states that he has found the *Oldhamia radiata* abundantly and very perfect in the vicinity of Eau Claire. In the bluff around this place there is a large exposure of Potsdam sandstone, quite fossiliferous, with numerous Trilobite impressions of several species, Pteropods and Lingulæ, besides Fucoidal impressions and wave marks. With the *Oldhamia radiata* occurs *Scolithus linearis*, and neither of them seems to extend as high as to the beginning of the other forms, or to the bottom of the sandstone exposures.

13. *Reef-building corals in the Tasmanian Tertiary.*—Professor P. Martin Duncan has described the new reef-building species *Heliastræa Tasmaniensis*, *Thamnastræa sera* and another species of Thamnastræa, from Cape Howe, Tasmania, 15° of latitude south of the present southern limit of the coral-reef seas in that part of the ocean.

14. *Carboniferous Pulmonates.* (From a letter to the editors, dated Montreal, July 24, 1876.)—In a recent visit to the South Joggins, in which I was assisted by Albert I. Hill, Jr., of the Cumberland Coal Mine, we succeeded in tracing *Pupa vetusta* to a higher level in the Coal formation than previously. A number of specimens were found in the material filling an erect Sigillaria in group XXVI of my section of the South Joggins, the same group in which Marsh's *Eosaurus* was found, and which has also afforded reptilian footprints. The bed is 222 feet above the main coal seam, 842 feet above the bed in which this shell was first discovered by Sir C. Lyell and myself, and about 2,000 feet above the lowest bed in which I have as yet found specimens. It thus appears that this little pulmonate continued to flourish in the Carboniferous swamps after its ancestors had been buried by 2,000 feet of sediment, including many beds of coal and nearly the

whole thickness of the productive Coal-measures. Its companion pulmonate, *Conulus priscus*, has as yet been found only in the lowest of the beds above referred to.

We were so fortunate as to discover, on the same expedition, another large Sigillaria stump, stored with reptilian bones; which it is hoped may afford some interesting additions to the land fauna of the Coal period. J. W. DAWSON.

15. *Brachiopods of the Swedish Paradoxides beds of Sweden.*—M. Linnarsson enumerates and describes the following Swedish Brachiopods (Swedish Acad. Sci., May 12, 1875): *Orthis Lindströmi* Linnarsson, *O. exporrecta* Linn., *O. Hicksi* Salt., *Lingulella* (?) *Nathorsti*, *Obolus* ——? *Acrotreta socialis* v. Seebach, *Obolella sagittalis* Salt., *Acrothele* (n. g.) *coriacea* Linn., *A. granulata*, *Kutorgina cingulata* Bill. var. *pusilla*, *Iphidea ornatella* Linn.

The Paradoxides and lower beds of Great Britain have thus far afforded only *Lingulella ferruginea* Salt., *L. primæva* Hicks, *Discina pileolus* Hicks, *Obolella sagittalis* Salt., *O. maculata* Hicks, *Orthis Hicksi* Salt., with perhaps *Kutorgina cingulata* Bill.

Including all *known* species, the number of species is small compared with that of the trilobites, the ratio being 29 to 150 of the latter. In general the Paradoxides beds are characterized by the most of their Brachiopoda having a corneous shell. The generic types *Kutorgina*, *Acrothele* and *Iphidea* have not been found in later beds.

16. *Geological Survey of Brazil.*—A recent letter to Prof. T. B. Comstock from Prof. C. F. Hartt, head of the Geological Survey of Brazil, states that he is preparing to send one division of his corps, probably under the direction of Mr. O. A. Derby, to make a careful examination of the Amazonian Country, and to connect the explorations of this region with those now in progress to the southward, in the interior of Brazil, and along the coast.

17. *Geological Map of Illinois.*—The geological map of Illinois, announced as nearly ready by Mr. Worthen in the last (sixth) volume of his Geological Report, has been published. It is of large size and well colored.

18. *Report on the Chemical, Mineralogical and Microscopical Characters of the Lavas of Vesuvius, from* 1631 *to* 1868; by Rev. SAMUEL HAUGHTON, of Trinity College, Dublin, and EDWARD HULL, Director of the Geological Survey of Ireland. 164 pp. 4to. 1876. Art. III of vol. xxvi, of Trans. R. Irish Acad., Dublin.—In this elaborate memoir the chemical and mineralogical part is by Dr. Haughton, aided in the chemical analyses by Mr. Wm. Early, and the microscopical, by Mr. Hull. The minerals found by the latter to be present in all the lavas, are leucite, anorthite, augite, magnetite and nephelite; in many of them, traces of sodalite, olivine, hornblende and mica; in several, sanidine, but this is rarely a prominent constituent; in a few, a little apatite. In the discussion of the chemical results with reference to the proportions of these mineral constituents, Dr. Haughton, by a simple

mathematical method, obtains the maximum and minimum of the amount possible for each constituent. The probable proportions of some of the constituents are then deduced from their relations in composition, and a mean possible value obtained for the rest. A comparison of the chemical composition of these minerals with the chemical composition of the lava, gives by subtraction, the chemical composition of the paste. The amount of paste is arrived at through the assumption that "*of the numerous possible solutions, that will be the occurring one in Nature which involves the largest amount of definite minerals and the least amount of indefinite paste.* Calculating from this basis, he arrives at the compositions of twenty Vesuvian lavas ejected at different times from 1631 to 1868, of which the following are examples:

	Gravina. 1631.	Granatello. 1631.	Della Scala. 1631.	C. de S.Vito. 1767.	C. de Salvatore. 1834.	The Atrio. 1855.	T.d.Greco. 1861.
Leucite,	38·2	33·6	40·6	41·4	39·7	36.8	34·2
Anorthite,	6·6	0·6	6·9	9·4	0·4	11·8	11·6
Magnetite,	7·14	4·45	4·9	6·9	9·7	3·35	3·74
Olivine,	tr.	tr.	tr.	tr.	tr.	tr.	----
Augite,	28·6	41·2	31·1	25·1	27·4	28·7	30·4
Hornblende,	tr.	tr.	----	----	tr.	tr.	----
Mica,	tr.	----	----	----	----	----	----
Nephelite,	10·5	10·0	6·5	8·6	11·2	11·5	10·9
Sodalite,	tr.	tr.	tr.	----	----	tr.	tr.
Apatite,	----	0.44	1·1	----	----	tr.	San.
Paste,	8·96	9·71	8·9	8·6	11·2	9·6	9·16
	100·00	100·00	100·0	100·0	100·0	100·0	100·00

The ingredients of the paste, as deduced by the method adopted, are silica, lime and protoxide of iron, and the mean composition, according to Dr. Haughton, corresponds to the formula $2RO, SiO_2$, "which represents a very fusible basic glass, of a brownish color from the large quantity of iron protoxide." The order of formation of the minerals, according to Dr. Haughton's views, is first the potash and soda minerals, leucite and nephelite or sodalite; then the magnesia mineral, augite; and lastly magnetite and anorthite.

The analysis of the Vesuvian augite which is taken for the calculations is that of Wedding, of augite from a lava of 1631, giving only 4·54 p. c. of protoxide of iron; the analysis of Rammelsberg, of the augite from a Vesuvian lava of 1858, gave 9·08 FeO. The constituent augite—one of the four always present—is hence one source of uncertainty in such calculations, for the maximum deduced (the amount usually taken by Dr. Haughton in his final results) will differ widely in the two cases. Further, the CaO not used by augite belongs to anorthite, and therefore the proportion of anorthite would also be different. There is, hence, reason to suspect that the calculated percentage of anorthite in several of the tabulated results is below the actual amount present in the lavas.

19. *On the crystallographic relations of the three types of Chondrodite (Humite).*—M. DESCLOIZEAUX in a recent letter, dated Paris, July 1st, 1876, gives the results of his researches in regard to the optical characters of chondrodite. These results are of especial interest as proving for the Swedish chondrodite, and the Vesuvian humite what has been shown by the writer to be true of the chondrodite from Brewster, N. Y.,—that the second and third types are monoclinic, not orthorhombic.

The principle conclusions of M. DesCloizeaux are, as follows.

The three types of humite, described by Scacchi, constitute three different species, closely related to each other in regard to form. The crystallographical and optical characters of the types are the following: Type I, humite from Vesuvius. Orthorhombic. Fundamental angles, as measured, *$A \wedge e^5 (pe^{\frac{1}{2}} = 001 \wedge 201) = 103° 47'$, $A \wedge i^2 (pa^3 = 001 \wedge 013) = 124° 16'$. The plane r^5 is made the fundamental pyramid with $A \wedge r^5 (ph^{\frac{1}{2}} = 001 \wedge 111) = 101° 39'$, and o^2 is made the unit prism, $B \wedge o^2 (100 \wedge 110) = 114° 50'$. Plane of the optic axes parallel to the base, with the acute bisectrix parallel to the shorter diagonal of the base. Dispersion weak, perhaps $\rho < v$; $2H\alpha$ (red rays) $= 78° 18' - 79°$.

Type II, chondrodite from Sweden. Monoclinic. Fundamental angles $A \wedge e^2 (ph = 001 \wedge 100) = 108° 58'$; $A \wedge i (pe' = 001 \wedge 011) = 122° 29'$; $C \wedge n^{2'} (g^1 h^3 = 010 \wedge 210) = 135° 41'$. The planes r^2 and r^3 are made the unit pyramids; $A \wedge r^2 (pd^{\frac{1}{2}} = 001 \wedge 111) = 125° 50'$, and $A \wedge r^3 (pb^{\frac{1}{2}} = 001 \wedge \bar{1}11) = 113° 28'$. Plane of the optic axes inclined to the front edge, and making an angle of about 30° with the base. The crystals, mostly twins, composed of hemitropic bands parallel to the base; two collections of these bands were observed in one crystal united by an irregular line not referable to any plane on the crystal. The number of these twinning bands varies with every specimen examined. Apparent axial angle (in oil), red rays, 86° 27′, blue, 86° 38′. Bisectrix positive, normal to the plane of symmetry. Dispersion also *crossed* (tournante). In several other crystals the axial angle was found to vary from 86° 14′ to 87° 20′.

Type III. Humite, color pale yellow, from Mt. Somma. Monoclinic. Fundamental angles; $A \wedge e^4 (ph' = 001 \wedge 100) = 100° 48'$; $A \wedge i^2 (pe^1 = 001 \wedge 011 = 125° 13')$; $C \wedge r^8 (g^1 m = 010 \wedge 110) = 154° 48'$. The planes r^4 and r^5 are taken as the unit pyramids: $A \wedge r^4 (pd^{\frac{1}{2}} = 001 \wedge 111) = 125° 47'$, $A \wedge r^5 = 001 \wedge \bar{1}11) = 119° 17'$. Plane of the optic axes inclined to the front edge and making an angle of about 11° with the base. Dispersion of the axes feeble $\rho < v$. Dispersion also crossed, scarcely appreciable. Bisectrix positive, normal to the plane of symmetry. Axial angle (in oil), red rays, 84° 38′–85° 4′. The white crystals, which are in appearance

* The letters given are those of Scacchi, the symbols which follow are those of DesCloizeaux, in his own and in Miller's method of notation.

simple, are mostly complex, being composed of parallel hemitropic bands. A yellow crystal, on the other hand, cut parallel to the plane of symmetry, showed a method of twinning analogous to that observed by Scacchi; it was composed of *five* individuals.

M. DesCloizeaux has also made an important observation tending to explain the well known variation in the composition of the three types. A small crystal, apparently of the first type, sliced, and examined optically, showed that it was penetrated irregularly by a crystal of the third type. M. Des Cloizeaux concludes from this that the former analyses cannot be considered reliable, and that the true composition can be obtained only from crystals which have previously been subjected to an optical examination. The second type seems to be the most homogeneous, and the one whose composition has been most certainly determined.

For the sake of comparison the results obtained by the writer from an optical examination of the chondrodite from Brewster, N. Y. (this Jour., III, x, 89, Aug., 1875, and xi, 201, Feb., 1876) are here cited. It will be seen that those since obtained by Des Cloizeaux for the chondrodite of Sweden and humite of Vesuvius agree very closely with them.

Type II, monoclinic; angle made by plane of optic axes with the base 25° 50′ (about 30°, DesCloizeaux). Bisectrix positive, normal to the plane of symmetry, $2H\alpha$ (red rays) $=88°\ 48'$ (86° 14′ –87° 20′, DesCloizeax).

Type III, monoclinic; angle made by the plane of the optic axes with the base about $7\frac{1}{2}°$ (11° DesCloizeaux, humite).

The measured angles upon the Brewster crystals, as was stated, were inconclusive except as proving that the obliquity did not exceed a very few minutes. How small the variation from the rectangular form is for crystals of the second type, as given by DesCloizeaux, may be judged from the following pairs of angles: $A \wedge e^2 = 109°\ 5'$, $A \wedge e^{2\prime} = 108°\ 58'$; $A \wedge r^3 = 113°\ 28'$, $A \wedge r^{3\prime} = 113°\ 25'$, etc.; if the crystals were orthorhombic, as has been assumed, the planes e^2 and $e^{2\prime}$ would be identical, and the angles on the base A would be the same; so also for r^3 and $r^{3\prime}$. In the third type DesCloizeaux makes the monoclinic variation from the rectangular form about *two* minutes. Some additional crystals of the second type of chondrodite recently obtained from Brewster, N. Y., offer an opportunity to test by accurate measurement the amount of the obliquity for the species, which the writer will not fail to avail himself of at an early date. E. S. DANA.

20. *Die Mineralien Badens nach ihrem Vorkommen*, von GUSTAV LEONHARD. 3d ed. 65 pp. 8vo. Stuttgart, 1876.—The Grand Duchy of Baden is remarkable for the variety and abundance of the minerals which it affords. This is explained, as remarked by Prof. Leonhard, by the wide range of rocks found in the country, embracing not only the older crystalline rocks with their many metallic veins, but also a large variety of igneous rocks, of which those of the Kaiserstuhl are especially rich in minerals, and also a considerable series of sedimentary rocks. The descriptions of

the individual minerals by Prof. Leonhard are concise and yet complete, and doubtless the work will prove highly valuable to those who have occasion to use it. E. S. D.

21. *Studien über Mineral-Pseudomorphosen. Inaugural-Dissertation* von F. E. GEINITZ. 56 pp. 8vo. Stuttgart, 1876.—Dr. Geinitz has subjected a large number of pseudomorphs to a careful study, particularly by means of the microscope, and the results of his work will be read with interest. The pamphlet is illustrated by a plate with a series of figures.

22. *New Minerals.*—Prof. C. U. SHEPARD has named and partially described the following new species:

Vanuxemite. Occurs in small irregular patches scattered through a firm ochery aggregate, proceeding from the decomposition of several zinc ores. Massive, impalpable, with an even or conchoidal fracture. Color white, dull. H.=2·5 – 3, G.=2·5. Does not adhere to the tongue, but emits a feeble clayey odor on being breathed upon. B. B. fuses readily to an opaque enamel. Composition SiO_2 35·64, AlO_3 11·70, ZnO 32·48 – 36, H_2O 14·80 – 19·88 = 99·70. Locality, Sterling Hill, N. J.

Keatingine. Considered "probably a new species." Closely resembles fowlerite in crystalline structure, but angles obtained on cleavage prisms 64° and 116°. Does not lose luster on weathering. H.=4·5 – 5, G.=3·33. B. B. fuses to a reddish semi-transparent glass. Composition SiO_2 47·8, MnO 27·7, ZnO 5·6, CaO 18·0, H_2O 0·8 = 99·9. Locality, Franklin, N. J., where it was found in a mass of yellow garnet.

Calcozincite. Massive, fine-granular; interpenetrated with fibres of asbestus and sussexite. Luster vitreous. Color light orange-red. Streak lemon-yellow. Translucent. H.=3·5, G.=3·95. Effervesces slightly with acid. B. B. blackens. Composition ZuO 81·00, CaO 7·56, CO_2 5·80, H_2O 4·26, MnO tr = 98·62.

Euchlorite. Massive, in coarse elongated scales. Color light olive-green. Powder pale green. Luster subpearly. H.=2·5 – 3, G.=2·71. B. B. fuses with difficulty on thin edges to a greenish-gray enamel. Decomposed by sulphuric acid. Composition SiO_2 35·51 – 38·46, AlO_3 6·80, FeO 15·52, (MgO 38·07), H_2O 6·10, 100. Locality, Chester, Mass., where it occurs in a layer on both sides of an extensive vein of albite.

Pelhamine. Forms irregular seams and masses sometimes a foot thick at the asbestus mine at Pelham, Mass. Resembles a black serpentine closely. Almost without luster. Powder dark greenish-gray. H.=5·0, G.=2·9 – 3·2. B. B. infusible. Composition SiO_2 38·40, AlO_3 2·80, FeO 15·52, (MgO 39·88), H_2O 3·40 = 100.

Prof. Shepard has also published a catalogue (8 pp.) of the minerals found within seventy-five miles of Amherst College, Mass. E. S. D.

III. Botany and Zoology.

1. *The Structure and Movements of the Leaves of Dionœa muscipula;* by Casimir De Candolle.—A neat paper, separately issued from the Geneva *Archives des Sciences Phys. et Nat.*, April, 1876, illustrated by two plates of anatomical details. One noteworthy suggestion—which has already been made here,—is that the sudden change of electrical current at the closing of the trap, ascertained by Burdon Sanderson (and much insisted on, on account of its accordance with what takes place in muscular motion), may have had its importance much overrated. The electro-capillary currents, which Becquerel long ago demonstrated in vegetable tissues generally, would almost necessarily be influenced in some such way by the displacements of liquid which would accompany any such abrupt change in the turgescence of the parenchyma. In some experiments made three years ago by Professor Trowbridge, of Harvard University (which, unfortunately, were not followed up), it was found that the strong bending of an internode of stem, without lesion, produced a similar electrical effect.

M. Casimir De Candolle fairly deduces from his experiments the conclusion that animal matter is not necessary to the development and vigor of *Dionœa*. He goes on to the conclusion that the animal matter of the insects caught is not directly utilized by the leaves. This does not follow. Very much evidence would be required to rebut the presumption that the organic matters absorbed are somehow (and even directly) utilized by the plant.

The independent movement of the border of the trap with its fringe of bristles is explained by the anatomical structure, which is, as it were, distinct from that of the main body. The glands are stated to belong to the epidermis only; but the excitable bristles are connected by the cellular bulb with the subjacent parenchyma, so that impressions upon the former may readily be transmitted to the latter. The closing of the trap results from the comparatively permanent elastic tension of the largely fibrous external part of the leaf. It opens by counter-action of the parenchyma of the upper or inner side, through turgescence; the closing results from the sudden diminution of the turgescence, in some unexplained way. In other words, the trap is held open, and at the proper moment is let go. A. G.

2. *Diatoms in Wheat-straw.*—The article by Professor P. B. Wilson, in this Journal, for May last, is referred to in Trimen's Journal of Botany for July, with the remark that the asserted discovery "is not very likely to meet with acceptance among botanists." The real nature of the siliceous molds or casts which Professor Wilson took for diatoms must have suggested itself to those familiar with such matters, and would have been indicated to the author of the communication if this had happened to receive attention before insertion. A. G.

3. *An Intoxicating Grass.*—Besides the "Dronk" grass, i. e., Drunk Grass, of the Dutch Colonists in S. Africa, of which we mentioned Dr. Shaw's account a year or two ago, it now appears that there is in Mongolia another grass with a corresponding native name and similar properties. The account of it is given by Dr. Hance, in the July number of Trimen's Journal of Botany, from specimens and information supplied by Dr. Bretschneider, of the Russian legation at Peking. It proves to be a new species of *Stipa*, brought from the Alachan mountains by a Roman Catholic Missionary, whose horses were disabled by its inebriating properties. The wandering Mongols of the region are familiar with this grass, and use vinegar as an antidote. A. G.

4. *Primitiæ Monographiæ Rosarum.*—The third fascicle of this interesting essay by M. CRÉPIN has come to hand. It deals with Asiatic Roses, and throws much light upon them. Our Cherokee Rose is recognized as of Chino-Japanese origin; but he proposes—apparently with reason—to retain Michaux's name of *Rosa lævigata*, on the ground that this cannot have been the original *R. Sinica.* If not, the name *R. lævigata* has priority. *R. acicularis* of Siberia is recognized as a N. American species of high northern regions; where also *R. Davurica* and *R. amblyotis* (one or both) also appear to occur. A classification of the *Cinnamoneæ* Roses is given; in which *R. alpina* and *R. blanda* belong to the series *Subinermes; R. stricta* and *R. acicularis* to the *Aciculares; R. Woodsii, R. Californica, R. laxa, R. cinnamonea*, and *R. amblyotis*, to the *Diacantheæ.* A. G.

5. *Does the Age of a tree influence the time of Leafing?*—Every one knows that very young trees in a nursery are apt to come rather earlier into leaf than full-grown trees of the species. But this is explained by the nearness to the ground and consequent higher temperature. The comparison should be made between the oldest available trees and other well-developed trees of moderate age. M. Alph. De Candolle caused observations of this kind to be made in two old botanic gardens, viz: those of Paris and of Pisa; and the results were negative,—in the Paris cases no difference; in the Pisa cases, an old Gingko and an old Walnut tree leafed earlier than young trees of the species, while the old tree of Horse-chestnut, *Sophora*, Linden, and *Pawlownia* were later than the young trees. A very full series of cases, of different species, would be needed for the elimination of individual peculiarities, often great in this respect. But M. De Candolle is able to refer to better data, viz: to one case in which the date of coming into leaf of a Horse-chestnut tree, has been carefully recorded for sixty-eight years, and another for fifty-seven years; both at Geneva. Of course any differences due to age would be small in comparison with those due to climate, yet they might be expected to be sensible in the long series of years, if age really made any difference. But the figures do not bring to view any tendency to either earlier or later leafing with the advance of years. M. De Candolle's notice is in the *Archives des Sciences de la Bibl. Universelle*, June, 1876. A. G.

6. *Practical Botany, Structural and Systematic; the latter portion being An Analytical Key to the wild Flowering Plants, Trees, Shrubs, ordinary Herbs, Sedges and Grasses of the Northern and Middle United States, east of the Mississippi*; by AUGUST KŒHLER, M.D., Professor of Botany in the College of Pharmacy of the city of New York. 400 pp., 12mo, copiously illustrated. New York. 1876. Henry Holt & Co.—The structural portion of the work occupies ninety-three pages, and is apparently very well worked up. A glossary of eighteen pages follows. The remainder of the volume is a key, which—ignoring classes, orders, and the like, and little mindful of the integrity of genera—leads directly to genus and to species when these are given, and is intended to serve the purpose of a flora or manual. It is on the dichotomal mode; the first couplet distinguishes *Phænogams* from *Cryptogams;* the former are at once divided into those which have flowers inclosed in an involucre, and those which have not; to the former only *Compositæ* are referred—one sees not why. Those without an involucre to several flowers divide next into perfect and diclinous flowers (which is a very variable matter), and so on. A lady botanist of advancing years, who was brought up under the Linnæan system, used to boast that she could find out the name of a plant by that in half the time required to do it through the natural system of classification. We could not gainsay the fact, and it would have been hardly polite to tell her that she knew little more of botany after the operation than before. The Linnæan system, however, is, if we mistake not, a better, and perhaps a surer one than the present substitute. A. G.

7. *Flora of Southwestern Colorado;* by T. S. BRANDEGEE. Reprinted from Hayden's Bulletin of the Geological and Geographical Survey of the Territories, vol. ii, no. 3.—A small pamphlet, containing an excellent contribution to our Botany. In six pages the character of the country and its vegetation along the San Juan, the Mesa Verde, and the sub-alpine neighboring higher regions, is succinctly and clearly sketched, and the dominant plants mentioned. "The Mesa Verde, a plain of 200 square miles, raised nearly a thousand feet above the surrounding country, is a prominent topographical feature of southwestern Colorado. Its surface is perfectly dry, the showers from the La Plata mountains rarely wetting it except upon the northern edge. *Juniperus occidentalis* covers almost the whole mesa, and it is to the abundance of this ungraceful bushy tree that the name of the green mesa is due." "The sub-alpine *Coniferæ* of the southwestern slope are mainly *Abies Engelmanni* and *grandis*. These two species, either together or in forests of one alone, cover the western slope down to the altitude of *Pinus ponderosa*, 9,000 feet, both species large and magnificent trees. *A. Engelmanni* is the only conifer found at the timber line. . . . *Abies concolor* was not seen upon the western slope, and not a tree of *A. grandis* could be found on the eastern slope. *Pinus ponderosa* is abundant at 8,000 feet altitude, and its large trees will furnish a great amount of lumber. *P.*

flexilis is not common; it grows at 8,500 feet, with *P. ponderosa*, *Abies grandis*, *Menziesii*, *Engelmanni* and *Douglasii*, all associated at this altitude." "*Pinus edulis* is said to fruit once in seven years." "The number of phænogamous plants growing in southwestern Colorado will not equal the 900 species that can be found on any similar area of the eastern slope. The impressions received by any one who has noticed the flora of the eastern slope, riding rapidly over southwestern Colorado, below 8,000 feet altitude, are: the great scarcity of all vegetation, the comparative abundance of rosaceous shrubs and *Artemisia tridentata* [sage-bush], the great number of the annual species of *Eriogonum*, the showy blossoms of *Malvaceæ*, and the few species of *Astragalus* and *Pentstenon*. Nevertheless, the characters of four new *Astragali* appear in the accompanying list, and of other new species the number is considerable. A. G.

8. *Darwiniana: Essays and Reviews pertaining to Darwinism;* by ASA GRAY. 396 pp. 8vo. New York: 1876. (D. Appleton & Co.)—The first two of the "Essays and Reviews" here collected into a volume, appeared in this Journal in 1860, not long after the publication of Darwin's first work, on the Origin of Species; and the others, subsequently, in this or other Journals of the country, excepting two, which are here first published. The chapters contain a clear exposition of the essential points in "Darwinism," and a discussion of the bearings of evolution-theories on Natural Theology, besides also a full review of the researches of Darwin and others on the subjects of Insectivorous and Climbing plants. The earlier articles were prepared in order to bring before American scientific readers the views set forth in Darwin's first work—not to advocate them; and, throughout the pages, as in all Dr. Gray has written on the subject, there is perfect fairness to both sides of the question. His extensive acquaintance with the plants of the world, and his oft-repeated perplexities—like those of other botanists—over the close relations among the species of some groups, and the difficulty of finding limits to variation, had prepared his mind for a discussion of any theory that might afford light and aid. His exposition of Darwinism was, therefore, the work of one ready to appreciate Darwin's facts and arguments, and ready to withhold assent if they were not satisfactory. In his paper of 1861—Chapter III—he says: "We are not disposed or prepared to take sides for or against the new hypothesis."

The next essay in the series published in 1863, presents some classes of facts connected with variation among plants, and indicates the "set and force of the current" toward a theory of derivation both in the facts and in the author; and the following essay—Chapter V—on the relations of North American to Northeast Asian vegetation, and of both to the Tertiary vegetation of the Arctic regions, first brought out in 1872, in his Address before the American Association, is an argument for the derivation of species from species, offering many strong facts in favor of the

derivation of the modern vegetation of the continents, by some method of variation, from Tertiary species.

At the same time, in the first as well as others of the essays, and especially in the seventh and the last, Dr. Gray argues, with the earnestness of personal faith, against Atheistic evolution, and in favor of design, or a divine purpose, in and throughout nature.

The work is commended to all readers who would understand what Darwinism in its essential features is, and who desire to learn, from one who knows all sides of the question, the relations of the subject to Natural Theology. J. D. D.

9. *Note on Gigantic Cephalopods,—a Correction.* By A. E. VERRILL.—In describing the large Cephalopods from Newfoundland in two former articles,* a serious mistake was made by me in respect to the lingual ribbon, or odontophore, of the specimen (No. 5) of *Architeuthis monachus.* (See this Journal, vol. ix, p. 128, Pl. iv, fig. 6.) The organ described and figured as the odontophore proves not to be that organ, but is doubtless a specialized chitinous portion of the lining of the mouth or pharynx, covered with sharp chitinous teeth and hard granules. The precise original position of this armed membrane I have not yet been able to determine, owing to the mutilation of the adjacent parts before the specimen came into my possession, and my error was largely due to the mutilation, for the armed band described was not adherent except by a slight attachment at one end, and it occupied nearly the position in which the odontophore should have been situated. Nevertheless I was fortunate enough to find, several months after my papers were printed, the genuine *odontophore* among the dirt and debris that had remained in the bottom of the can in which the specimen had originally been sent from Newfoundland. This odontophore is about 70mm. in length, with the dentigerous portion, where widest, about 12mm. in width. The teeth are in seven rows, with an exterior row of small unarmed plates on each side, thus conforming to the arrangement in the other ten-armed cephalopods. The teeth are deep amber-colored and not unlike those of *Loligo* and *Ommastrephes* in form. Those of the median row have three fangs, the central one longest; those on the next row, on either side, have two fangs; while those of the two outer lateral rows on each side are simple, acute and strongly curved. A full description and figures, which have hitherto been delayed by an unusual pressure of other work, will soon be published in this Journal.

In this connection I wish also to record the occurrence of another gigantic species of cephalopod discovered by Mr. W. H. Dall, on the coast of Alaska. He found three specimens thrown upon the beach in April and May, 1872, and made some very valuable drawings of them while fresh He also preserved the pharynx, beak, odontophore, part of the "bone," and portions of the arms of one of the specimens, and has generously placed them in

* This Journal, vol. ix, 1875, pp. 123, 177. Also American Naturalist, vol. ix, Jan. and Feb., 1875, pp. 21, 78.

my hands for examination, together with his drawings, measurements and notes. The largest specimen had a total length of 14 feet, but the ends of the tentacular arms had been destroyed; length from tail to root of arms, 102 inches; to front edge of mantle, 91·5 inches; width across fins, 42 inches; diameter of body, 18 inches; slender portion of tentacular arms remaining, 61 inches; diameter, 2·5 inches; shorter arms (ends and suckers gone), 30 to 40 inches; diameter of eyes, 1·25 inches; length of pen, 89 inches. The eyes were furnished with lids. The few suckers remaining on some of the shorter arms of one specimen were alternate in two rows and agree with those of *Ommastrephes*. The color was reddish, in fine red dots on a white ground, a darker stripe on the outer median line of the arms. Tail acutely pointed. For this species Mr. Dall has proposed the name of *Ommastrephes robustus*. It is probably a genuine *Ommastrephes*, or if not, it is at least an extremely closely allied genus. I hope soon to publish detailed descriptions and figures of this very interesting species, which forms part of the exceedingly valuable collection made by Mr. Dall on the coast of Alaska.

10. *Comparative Zoology, Structural and Systematic;* by JAMES ORTON. New York: Harper & Brothers. 8vo, 384 pp. 350 wood cuts. 1876.—In the preface to this work the author states that "It is designed solely as a manual of instruction. It is not a work of reference, nor a treatise. So far as a book is encyclopediac, it is unfit for a text-book. This is prepared on the principle of 'just enough and no more.' It aims to present clearly, and in a somewhat new form, the established facts and principles of Zoology. All theoretical and debatable points, and every fact or statement, however valuable, which is not absolutely necessary to a clear and adequate conception of the leading principles, are omitted."

Probably very few, if any, zoölogists will admit that the author has succeeded in carrying these ideas into practice, and many may doubt whether, in some cases, failure in this respect may not have been more desirable than success. To have excluded all that is "debatable" or "theoretical" would certainly have very much reduced the size of this volume. And certainly "just enough and no more" is far from applicable to many chapters. The book is in most respects not unlike other similar compilations, and with about the average number of errors and inaccuracies, many of which will doubtless disappear in a second edition, but should have been avoided in the first. More than half of the volume is devoted to the general facts and principles of comparative anatomy and physiology, some portions being treated with perhaps unnecessary fullness, while others of more general importance and interest (e. g., reproduction and embryology) are treated with unnecessary brevity and reserve, due perhaps to the fact, as stated in the preface, of its "being fitted for High Schools and Mixed Schools by its language and illustrations." How far this consideration should be allowed to interfere with a clear statement of the

fundamental facts of biological science is a question upon which teachers are not likely to agree at present. The system of presenting the comparative anatomy before the systematic zoology is a practice by no means new in text books, and one that has its disadvantages as well as its advantages. An intermediate course has been found preferable by the writer. This book is profusely illustrated, but we regret to notice that very few, if any, of the cuts are new, many of them having done much service before in several text books and popular treatises, while a very large proportion have been borrowed from European books, and illustrate foreign animals, even when far better figures of corresponding American species are easily available. Formerly, when but few of our American animals had been well figured, there was some excuse for borrowing and copying the figures of European animals, but the case has been entirely changed within twenty years, for the American species are now very well and very fully figured in numerous works. Prof. S. Tenney has, in this respect, set an excellent example in his Manual of Zoology, where the figures are excellent and mostly from the standard works on American Zoology. It is to be presumed, however, that this glaring defect is to be attributed far more to the publishers than to the author of the present work. The false economy which so often impels American publishers to borrow for text books stale foreign cuts instead of employing fresh and useful ones, drawn from native animals, should be discountenanced by every naturalist. V.

11. *Geographical Variation among North American Mammals, especially in respect to size. Sexual, individual and geographical variation in Leucosticte tephrocotis.* By J. A. ALLEN. Extracted from the Bulletin of the Geological and Geographical Survey of the Territories, Vol. II, No. 4.—In the former paper Mr. Allen contributed a great amount of information on the variation of many of our larger mammals. His conclusions are largely based upon a study of the very large series of skulls belonging to the Smithsonian Institution. He shows that while most northern and Arctic animals decrease in size southward, the reverse of this is true of other species having a southern distribution, and that the same holds good for genera and families as well as for species.* Mr. Allen, in this paper, reverses some of his opinions, expressed in former papers, respecting the identity of some of the North American Mammals with those of Europe. He now admits that the common black bear (*Ursus Americanus*) is a species distinct from the brown bear (*U. arctos*) of Europe, but he states that the barren ground bear is identical with *U. arctos*, and considers the grizzly bear a "subspecies" of the latter. He now admits the American sable to be distinct from all the European forms. The common red fox he considers a "subspecies" of the red fox of Europe. He questions the specific distinctness of the Canada lynx from the bay lynx (*L. rufus*) and regards it as probably only a "subspecies."

* Similar laws have been found by us to hold good for the marine invertebrates of our coasts.

In the second paper the author shows that in all the American species of *Leucosticte* there is really considerable sexual variation, both as to size and color, and that the species also vary geographically. v.

12. *Archivos do Museu Nacional do Rio de Janeiro.* Vol. I. 1st Trimestre. 30 pp. 4to. 1876.—The first number of this new periodical is handsomely printed and illustrated. It contains valuable papers on Brazilian archeology, by Prof. C. F. Hartt, and by Carlos Wiener. v.

13. *Etudes sur les Echinoïdées*, par S. Loven, from Kongl. Svenska, Vetenskaps-Akad. Handligar. Vol. ii, No. 7. 4to, with 53 plates. 1875.—This very important work, although published some time ago, has only just reached us. It is mainly devoted to a very thorough and complete study of the skeleton and external organs of the entire group of Echini. A few new forms are also described and figured. v.

14. *Bulletin of the United States National Museum.* No. 5. *Catalogue of the Fishes of the Bermudas*, by G. Brown Goode; No. 6. *Classification of the Collection to illustrate the Animal Resources of the United States*, by G. Brown Goode. 1876.—The former is a very useful contribution to the Ichthyology of Bermuda and our own adjacent waters. It includes descriptions of many species from life, the synonymy, local names, etc.

The second work is a very comprehensive scheme, showing the possibility and manner of making such a collection complete. This system of classification has been carried out in the extensive collections illustrating this department in the Government Building of the Centennial Exhibition. v.

15. *Contributions to the Natural History of Kerguelen Island, made in connection with the U. S. Transit of Venus Expedition*, by J. H. Kidder, M.D. Part II. May, 1876.—This final part contains the Oology, by J. H. Kidder and Dr. Elliott Coues; Botany, the Phænogamia, Filices and Lycopodiaceæ, revised by Prof. A. Gray, the Musci, by Thos. P. James, the Lichens, by Prof. Edw. Tuckerman, the Algæ, by Dr. W. G. Farlow; Geology, including a list of the rocks and minerals, by Dr. F. M. Endlich; Mammals, by Dr. Kidder; Fishes, determined by Prof. Theodore Gill; Mollusks, by W. H. Dall; Insects, by Dr. Kidder, the Diptera having been determined by C. R. Osten Sacken, and the Neuroptera, by Dr. H. A. Hagen; Crustaceans, by Prof. Sidney I. Smith; Annelids and Echinoderms, by A. E. Verrill; Notes on the specimens obtained, by Dr. E. Kershner and Mr. I. Russell, in New Zealand, etc., including minerals, birds, fishes, skulls, hydroids, etc.; and finally, an important study of the comparative anatomy and affinities of *Chionis minor*, by Dr. Kidder and Dr. Coues. The authors constitute a new tribe (*Chionomorphæ*) to include this species and *C. alba.* They also think it necessary to place the former in a new genus (*Chionarchus*). They regard this small and peculiar group as representing an ancient or ancestral type intermediate in some respects between the modern gulls

and plovers. Among the mollusks, Mr. Dall, in addition to other useful matters, describes a new species of *Lepton* (*L. parasiticum*) which lives upon the test of the sea-urchin (*Tripylus cordatus* V.), chiefly along the ambulacra near the mouth; a new genus and species, *Kidderia minuta*, related to *Modiolarca;* and a new genus and species of Chitonidæ (*Hemiarthrum setulosum*) is contributed by Dr. P. P. Carpenter. Mr. Dall also gives a new generic name (*Eatoniella*) to the small Rissoidæ described by Mr. E. A. Smith under the preoccupied name, *Eatonia*. Among the insects, new facts concerning the remarkable wingless diptera are given, and Dr. Hagen has described a new form (*Rhyopsocus eclipticus*). Among the crustaceans, Prof. Smith has described, as new, *Hyale villosa* and *Lysianassa Kidderi*, and as doubtful, *Atylus*(?) *australis* Miers(?), and gives useful notes on other species. Among Annelids, *Nereis antarctica* and *Neottis spectabilis*,* are described as new, with a revision of the characters of the latter genus. Among Echinoderms, *Pentactella lævigata*, *Hemiaster cordatus*,† *Asterias rupicola*, from Kerguelen Island, and *Astrophyton australe* from Tasmania are described as new, while *Ophioglypha hexactis* Smith is also fully described. Of Anthozoa, two species, *Anthopodium australe* V., new sp., and *Primnoella Australasiæ* Gray, both from New Zealand, are described. V.

V. Miscellaneous Scientific Intelligence.

1. *Elements of Physical Manipulation;* by Edward C. Pickering, Prof. Physics Massachusetts Institute of Technology. Part II. pp. x, 316, 8vo. New York, 1876. (Hurd & Houghton.)—In preparing this volume as a completion of the work of which the first part was published three years ago, the author has greatly extended the range of subjects treated, and has included in this portion topics belonging to a number of kindred branches of science. The first 108 pages are devoted to experiments illustrating electricity and heat, with descriptions of the apparatus required and the modes of conducting the various researches. Then follow chapters upon mechanical engineering, meteorology, practical astronomy and lantern projections. At the end are three

* In the Annals and Magazine of Natural History, April, 1876, p. 318, Mr. W. C. McIntosh has published descriptions of several Kerguelen Annelida from the English expedition. The *Nereis Eatoni* described by him, may, perhaps, be the same as our *N. antarctica*, or a sexual form of it; and his *Neottis antarctica*, may be identical with our *N. spectabilis*, but his descriptions are not sufficiently detailed to permit an accurate determination of these points. The tube of his *Neottis* appears to be quite unlike that of ours, but this may be due to difference of locality. Although this part of Dr. Kidder's report had been in type and the proof had been corrected several months previous to its publication, early in May, the paper by Dr. McIntosh has priority of actual publication.

† Mr. A. Agassiz has published, in the Proceedings of the American Academy, an interesting paper on the young stages of this species, found by the writer inhabiting the deep ambulacral furrows of the female specimens, where they were effectually concealed and defended by the longer spines projecting inward from the borders.

appendices, in the first of which certain topics in electricity are treated more fully than in the main portion of the volume, with the addition of a number of important matters pertaining thereto. The second contains a variety of tables and data useful in physical computations. The third is made up of general directions with reference to physical laboratories, a valuable list of works of reference, and an excellent collection of additional experiments, of varying difficulty, and some of them fitted to tax the skill of the best trained student. The same practical good sense is displayed in the selection and arrangement of the subjects as in the first part, and the two volumes constitute not only a very important contribution to the resources of the student, but also an invaluable aid to instructors in physical science. The cuts which accompany the text, though sufficient for the purposes of illustration, are hardly consistent in quality with the rest of the work, and if, in the endeavor to attain clearness and conciseness, the ordinary graces of style have been sometimes sacrificed, the reader will count it no serious imperfection in view of the very substantial excellence of the work. A. W. W.

2. *Treatise on the Mechanical Theory of Heat, and its applications to the Steam Engine, etc.;* by R. S. McCulloch, Civil Engineer and Professor of Mechanics in Washington and Lee University, Va. pp. xii, 288, 8vo. New York, 1876. (Van Nostrand.) —This volume contains a clear and simple mathematical exposition of the modern theory of heat, with many of its applications in practical matters, especially to the steam engine and other machines for the generation of power by means of heat. It begins with an historical sketch, giving an account of the various steps by which the mechanical theory of heat has been developed, and the historical method is kept in view throughout the book. The author in his preface "acknowledges his indebtedness to the profound views of his friend, Prof. W. H. C. Bartlett, whose mathematical exposition of the unity of physical action has been the point of departure of his own labors." A. W. W.

3. *On the Theory of Ventilation;* by F. S. B. Francois de Chaumont, M.D.—In my previous paper (Jan. 28th, 1875) I endeavored to establish a basis for calculating the amount of fresh air necessary to keep an air-space sufficiently pure for health, taking the carbonic acid as the measure. The results showed that the mean amount of carbonic acid as respiratory impurity in air undistinguishable by the sense of smell from fresh external air was under 0·2000 per 1000 volumes. My object in the present note is to call attention to the relative effects of temperature and humidity upon the condition of air, as calculated from the same observations.

Temperature.	Humidity.	Carbonic acid.
63° F.	73 per cent.	0·1943 per 1000 volumes.

If, now, we arrange the observations according as they differ from the above standard of temperature and humidity, and note the record of sensation attached to each, we may ascertain how far

the said record departs (if at all) from what it ought to have been as calculated from the actual CO_2. To do this we may employ the numerical values of the different classes, taking No. 1 (fresh) as unity, thus:—

Class.	Sensation.	Value.
No. 1.	Fresh	1·00
2.	Rather close	2·13
3.	Close	3·46
4.	Extremely close	4·66

Taking each observation and dividing the CO_2 found by the mean quantity of No. 1, viz: 0·1943, we get a number which will give the *theoretical* value of its effect upon the senses; and by comparing this with the *actual* value of the *recorded* sensation, we can note whether the difference is *plus* or *minus*, if any. All observed quantities of CO_2 below 0·1943 are considered equal to that number, and all quantities above 0·9054 as equal to it, as the sense of smell does not seem capable of differentiating quantities except between those limits.

Out of 458 fully recorded cases, 186 gave a recorded sensation *in excess* of the theoretical value—that is, the air seemed less pure than would have been expected from its CO_2. In these the average temperature and humidity were both above Class 1.

152 cases gave a recorded sensation *below* the theoretical value —that is, the air seemed purer than would have been expected from its CO_2. In those cases the average temperature was above, but the average humidity below the mean of Class 1.

120 cases gave a recorded sensation that exactly corresponded with the theoretical value. In those cases the average temperature was above, and the average humidity below the mean of Class 1.

Arranging these results and putting F for the temperature in degrees of Fahrenheit, and H for the humidity per cent, we have:—

$$+ 58°{\cdot}6\,F + 86\,H = + 197.70 \quad [1]$$ { Aggregate difference of the recorded and the theoretical value of sensation.

$$+ 230{\cdot}8\,F - 82\,H = - 117{\cdot}37 \quad [2]$$ Do.

$$+ 244{\cdot}0\,F - 91\,H = 0 \quad [3]$$ Do.

Adding the two last equations, we have,

$$+ 474°{\cdot}8\,F - 173\,H = - 117{\cdot}37 \quad [4]$$ Do.

From [1] and [4] we can determine the respective values of F and H, which are as follows:

$$F = 0{\cdot}4730 \qquad H = 1{\cdot}9765$$

Or, stated in terms of CO_2, by multiplying by 0·1943,

$$F = 0{\cdot}0919 \qquad H = 0{\cdot}3833 \text{ per } 1000 \text{ vols.}$$

Taking F as unity, we have,

$$F : H :: 1{\cdot}000 : 4{\cdot}1789$$

Or an increase of 1 per cent of humidity has as much influence on the condition of an air-space (as judged of by the sense of smell) as a rise of 4°·18 of temperature in Fahrenheit's scale, equal to 2°·32 Centigrade, or 1°·86 Reaumur.

This may be taken as a proof of the powerful influence exercised by a *damp* atmosphere, corroborating the conclusions arrived at by ordinary experience; and it follows that as much care ought to be taken to ensure proper hygrometric conditions as to maintain a sufficiently high temperature. This is especially the case in the wards or chambers of the sick, in which regular observations with the wet and dry-bulb thermometers ought to be made; these would probably give a valuable indication of the condition of the ventilation, either along with or in the absence of other more detailed investigations. Thus a room at the temperature of 60° F. and with 88 per cent of humidity contains 5·1 grains of vapor per cubic foot: suppose the external air to be at 50° F. with the same humidity, 88 per cent; this would give 3·6 grains of vapor per cubic foot; to reduce the humidity in the room to 73 per cent, or 4·2 grains per cubic foot, we must add the following amount of external air,

$$\frac{5{\cdot}1 - 4{\cdot}2}{4{\cdot}2 - 3{\cdot}6} = 1{\cdot}5,$$

or once and a half the volume of air in the room. If the inmates have each 1000 cubic feet of space, it follows that either their supply of fresh air is short by 1500 cubic feet per head per hour, or else that there are sources of excessive humidity within the air-space which demand immediate removal.—*Proceedings Royal Society*, London, May 4, 1876.

4. *Ninth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology.* 54 pp. 8vo.—The report of the Curator, Mr. F. W. Putnam, contains an account of the various recent additions to the Museum, the largest of which is the collection from Peru and Bolivia, made by Mr. Alexander Agassiz and Mr. S. W. Garman, during their journey in South America. This collection, obtained at a large expense, was the gift, even to the cost of transportation, of Mr. Agassiz. It includes several mummies, pottery, idols, cloth and articles of clothing, balls of thread, spindles, and other articles connected with weaving, "which art was developed to a very high state by the ancient Peruvians;" also work boxes, ornaments and beads of silver, copper, shell, and stone, fishing nets, and many other articles; all taken from an ancient burial-place at Ancon. The adjoining burial-place at Chancay, afforded Mr. Agassiz about 70 jars, vases, and other vessels, with terra cotta idols and images." The two illustrate well the ceramic art of the ancient people from the central portion of the Peruvian coast. Besides these, the collections contain numerous articles from Pasagua. One of the five crania from Pasagua had been distorted by circular pressure, giving it the pyramidal form of some crania from near Lake Titicaca, while three others were of natural form and

not at all like the broad depressed skulls of Ancon. A large collection of hair was obtained from Pasagua, showing "not only the peculiar modes of braiding, but also the fact that hair other than that belonging naturally to the head was worn to a great extent in the form of 'switches,' and that even these ancient people were familiar with the use of the 'rats' of the modern hair-dressers." Among the other objects from the same place were a hair-comb, a head-dress of feathers, a sinker attached to a fishing-line, large dishes, a cup of basket work, articles of clothing, fishing nets, pottery. Pacasmayo afforded Mr. Agassiz jars and vases of black clay highly ornamented, many having the human form or that of monkeys and other animals moulded over them; and Titicaca, a series of graceful jars, reminding of Etruscan art, and various objects quite different from those of other parts of Peru. The collections also contain numerous articles illustrating the manner of life, etc., of the modern Indians.

The Museum has also received large collections from the Smithsonian Institution from explorations in California, including 100 human crania, stone mortars and pots, a cup of serpentine, etc.

The Geographical Distribution of Animals, by A. R. Wallace. 2 vols. 8vo, with colored maps and many illustrations. 1876. London. (Macmillan & Co.)

Carte Géologique du Bassin Houiller de Liège, par M. Julien de Macar. 1876. Liège. (E. Decq.)

Proceedings of the American Association for the Advancement of Science, 24th Meeting, held at Detroit, Michigan, August, 1875. Salem, 1876.

Contributions from the Laboratory of the State University. On the various methods of separating and determining Baryum, Strontium and Calcium. Part I: Determination of Baryum. By P. Schweitzer, Ph.D., Prof. Analytical and Applied Chemistry. From the Catalogue of the University of the State of Missouri. 36 pp. 8vo. Jefferson City, Missouri, 1876.

Geschichte der Sulfoverbindungen mit besonderer Berücksichtigung der Sulfosäuren der methylirten und äthylirten Aniline. By George Adams Smyth, of Maine. Doctorate Inaugural Dissertation at the Friedrich Wilhelms-Universität, Berlin. 43 pp. 8vo. Berlin, 1876.

Science Primers, edited by Professors Huxley, Roscoe, and Balfour Stewart. VIII. Botany, by J. D. Hooker, C.B., F.R.S. 118 pp. 18mo, with illustrations. 1876. (New York, D. Appleton & Co.)

OBITUARY.

Professor McCheeney, of Missouri, who accompanied the geological party under Professor Shaler to the Cumberland Gap, was killed while in the excavation he had just made in an Indian mound. It seems that the people of the vicinity crowded around the edges, which gave way, and quite a number were precipitated in the hole. When the excavation was cleared out again, it was found that Professor McCheeney was stooping when the accident occurred, the result being that his neck was broken. He died almost immediately.—*Letter of Prof. Shaler, dated Camp Harvard, Cumberland Camp, July* 10.

Edward Newman, F.Z.S., editor of the Zoologist and Entomologist, recently died in London, at the age of seventy-five years.

Ehrenberg, the eminent microscopic investigator of Berlin, died on the twenty-seventh of last June.